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Analyzing Turkey's Elementary and Middle School Mathematics Standards with General Topic Trace Mapping

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Abstract

The purpose of this study was to conduct a comparative analysis for Turkey's elementary and middle school mathematics standards using the general topic trace mapping method. Turkey's standards were compared with the Common Core State Standards for Mathematics in the United States and also with the mathematics curriculum of the countries that ranked high in international mathematics achievement tests. The curriculum comparison was conducted from three perspectives: Number of topics at each grade level, topic repetition, and organization of mathematics topics. Data analysis showed that compared to the other countries included in the study, Turkey's elementary school standards include more topics, whereas the middle school standards include fewer topics. The topic repetition analysis yielded an average of 3.97 years for both Turkey's standards and the CCSS for mathematics. With respect to topic organization, a three-tier pattern was observed in Turkey's mathematics standards. The article discusses possible revisions in Turkey's standards for improvement.

Keywords

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Introduction

Scientific and technological developments, new jobs created by these developments, and research results in the field of education require educating students who possess a high level of mathematical knowledge, have good problem solving skills, and think reflectively. In accordance with these requirements, many countries are taking steps to improve their mathematics education. One of the steps taken for improving mathematics education is revising mathematics standards. Mathematics standards determine which topics to be learned in mathematics lessons and how these topics are organized throughout the school year, and therefore influence students' success in mathematics (Hook, Bishop, & Hook, 2007; Schmidt, Houang, & Cogan, 2002). In Turkey, in order to keep up with the new age, increase equity in education, educate more democratic citizens, create a student-centered education system, and increase students' mathematics achievement, a new set of the mathematics standards were developed in 2005 (National Board of Education [NBE], 2005; Ministry of National Education [MoNE], 2009). With the change in the education system from "5 years elementary school + 3 years middle school" model to "4 years elementary school + 4 years middle school" model, the middle school mathematics standards were updated in 2013 (MoNE, 2013).

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Numerous studies have been conducted to evaluate Turkey's 2005 Mathematics Standards. These studies can be divided into two general categories based on the research methods used. The first group studies used survey methods and investigated the teachers', students' and parents' opinions on the mathematics standards (e.g., Aksu, 2008; Bukova-Güzel & Alkan, 2005; Halat, 2007; Kay & Halat, 2009). The second group studies conducted document analysis to analyze the whole or some part of the standards (e.g., Delil & Güleş, 2007; Olkun, 2005; Umay, Akkuş, & Paksu, 2006; Zembat, 2010). These studies certainly have provided important contributions to the literature. However, these studies lack providing sufficient contributions for analyzing the standards in a systematic manner to compare it with the standards of other countries. The aim of this study is to analyze Turkey's current elementary and middle school mathematics standards in a systematic way and to compare Turkey's mathematics standards with the standards of high performing countries in international tests. The study is original since it uses General Topic Trace Mapping [GTTM] (Schmidt, Wang & McKnight, 2005) method to analyze Turkey's mathematics standards and this method has not been used in the Turkish context before. The study aims to contribute to the standard development efforts in Turkey and in other countries by introducing the GTTM method for analyzing standards. In the article the word "standard" refers to mathematics standards.

Kay and Halat (2009) who used survey methods to evaluate the 2005 standards found that parents did not have a full understanding of why the standards were developed in their study with 317 parents. Bukova-Güzel and Alkan (2005) investigated the perspectives of 600 students selected from the pilot schools where the new standards were implemented, and found that the students were reluctant to take responsibility for their own learning, a process that was promoted in the standards. Halat (2007) surveyed 247 classroom teachers about implementing the 2005 standards. The study revealed that the teachers had difficulties in implementing the standards since they were not provided sufficient guidance. Despite these challenges, the teachers expressed that the activities included in the standards motivated students and encouraged them to think mathematically. Aksu (2008) examined the opinions of 280 mathematics teachers in order to evaluate the middle school mathematics standards. Approximately 55% of the participants stated that the standards were at a desired level. Besides the positive opinions, the study also revealed opinions that pointed out possible weaknesses of the standards. For example, approximately 64% of the teachers reported that there was a lack of consistency between the content of the standards and the strands of mathematics. Approximately half of the teachers expressed that the standards are not excessively repetitive, while the other half were undecided (20%) or thought that the standards were repetitive (30%). Literature findings indicate the need for analyzing the organization of standards in detail and in a systematic way. Since the study presented in this article is conducted to pursue such an analysis, it will extend the findings of the existing literature, and help the future standard revision efforts by providing new information about the structure of the standards.

The second group of studies on mathematics standards examined the content of the standards. Some of these studies reported that 2005 standards are proposing a more active role for students compared to previous standards (Delil & Güleş, 2007; Olkun, 2005), and are in accordance with the changing norms in education in recent years (Umay et al., 2006). Some other researchers shared their opinions about the weaknesses of the standards. For example, Olkun (2005), who performed a comprehensive review on the 2005 standards reported that the benchmarks about geometry, skip counting, unit fractions are weakly written and their organization throughout the years are not well structured, and made recommendations to improve the content and organization of the standards. Similarly, Zembat (2010) examined the measurement standards and explained that the standards emphasize the procedural meaning of measurement. He offered suggestions for adapting the standards to promote the students' conceptual understanding of measurement concepts.

Another study examining the standards' content was carried out by Umay et al. (2006). They examined the 2005 elementary school standards in comparison to principles and standards for school mathematics published in 2000 by the National Council of Teachers of Mathematics [NCTM] in the

United States of America [USA]. The researchers explained that overall the 2005 standards were in line with the NCTM principles and standards, however some concepts such as equity could have been explained more clearly in Turkey's standards. It should be noted here that NCTM principles and standards are not a set of standards that are ready to be implemented; rather they were written as a guideline for standard writers (NCTM, 2000). Although comparing Turkey's standards with NCTM principles and standards might provide useful information about Turkey's standards, this comparison is not enough. If Turkey wants to provide world-class education, its standards should be compared with the intended standards of a state or a country, in particular with the standards of high achieving countries. The study presented in this article, is a step towards this end.

Undoubtedly, evaluating the content of standards with expert opinion in light of research is a very important part of the standard development or revision process. Important aspects of standard evaluation include analyzing the content of standards, their wording, and how to organize the subject matter throughout the years. Beside these analyses, objective and scientific methods that allow examining the standards all at once might offer a different perspective. A method developed for this purpose is GTTM. GTTM was developed by the Third International Mathematics and Science Study [TIMSS] researchers to examine and compare the curriculum of different countries (Schmidt et al., 2005).

TIMSS 1995 researchers examined the mathematics standards of 37 countries using the GTTM method. Since this study also used the GTTM method, the development process of this method and how it was used are summarized below (Schmidt et al., 2002; Schmidt et al., 1997; Schmidt et al., 2005):

• Mathematics topics were subtitled into 44 categories after examining the standards of countries participated in TIMSS and taking into account the topics included in TIMSS mathematics tests. Then, 32 topics were selected to enable comparisons between different countries. All mathematics topics are not covered in these 32 topics selected.

• For each of the 37 countries, a GTTM table was created to indicate whether the selected 32 topics are included at the grade levels 1 through 8.

• The standards of the top-achieving countries in TIMSS were examined to find out whether there is a pattern among them. The most successful 6 countries in mathematics were determined for this purpose and A + symbol was used to denote these countries. A+ countries are Singapore, Korea, Japan, Hong Kong, Belgium and the Czech Republic.

• In order to determine the mathematics topics deemed important by the majority of A+ countries, a common GTTM table was created. This table was constructed by using the topics included at least in four of the six countries' standards. This GTTM table was called "A+ composite". A+ composite can be seen in Table 3 in the findings section.

Examination of the A + countries' standards revealed some common features (Schmidt et al., 2002; Schmidt et al., 1997; Schmidt et al., 2005). First, it was observed that the mathematics topics were organized in three tiers in A+ composite. The first tier (1-4 grade levels) focuses on arithmetic including fractions, decimals, rounding, and estimation. The second tier (5-6 grade level) serves as a bridge between the first tier and third tier. Tier-two includes few arithmetic topics, and introduce more advanced mathematics topics such as percentages, integers, proportions, two-dimensional coordinate geometry, and geometric transformations. Seventh and 8th grade levels cover the third tier that consists of more advanced number topics (e.g., exponential numbers, radical numbers, and rational numbers), geometry (e.g., three-dimensional geometry, congruence and similarity), and algebra (e.g., functions, slope). According to Schmidt et al. (2002), some topics such as measurement units, equations and formulas, data representation and analysis support the continuity of A+ composite by being included across all three tiers. Also, Schmidt et al. (2002) noted that the A+ composite has an upper-triangular shape as a result of the three-tier structure. (Please refer to Table 3 for this visual inference.)

Another pattern observed about the A+ composite is that the topics are not repeated excessively. In comparison to A+ composite that has a 3-tier structure and avoid excessive repetition of the topics, the U.S. states standards intended to teach many more mathematics topics at each grade level and thus the topics remained in the standards for longer periods of time (Schmidt et al ., 2002). In other words, the A+ composite organizes mathematics topics so that they build on each other and reflects the hierarchical nature of the mathematics discipline. On the other hand, the U.S. states seemed to organize mathematics as a set of disconnected topics. The findings of TIMSS and similar research studies accelerated curriculum development efforts in the US. One result of these efforts was the development of the Common Core State Standards [CCSS]. CCSS was written by the joint efforts of many researchers, teachers, and leading experts (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). The CCSS for mathematics has been adopted in many states.

This study sought to answer the following questions. According to the general topic trace mapping, how is mathematics organized in Turkey's elementary and middle school mathematics standards? How does the content and organization of Turkey's standards compare with the content and organization of the A+ composite standards and the CCSS for mathematics?

Method

The study examined Turkey's elementary (renewed in 2005, includes grades 1-4) and middle (updated in 2013, includes grades 5-8) school mathematics standards using the GTTM method. This method was chosen since it would provide data about how mathematics is organized in Turkey's standards, as well as allow a comparison between Turkey's standards and the CCSS for mathematics and with the standards of six highest achieving countries in TIMSS 1995. The six top-achieving countries were not only successful in TIMSS 1995, they were also successful in other international exams such as the Programme for International Student Assessment (PISA) conducted in 2009 (The Organisation for Economic Cooperation and Development [OECD], 2010). The GTTM method was created in the 90s, though it still remains up to date. For example, GTTM has been one of the methods used to evaluate the CCSS for mathematics (Schmidt & Houang, 2012). The method is used by researchers since it is viewed as reliable and replicable, and the inferences resulting from GTTM tables are guided by empirical research studies of student achievement (Schoen, Erbilgin, & Hacıömeroğlu, 2011).

In order to conduct the study, first, the mathematics topics in GTTM table were translated into Turkish by the author. The translation was checked and approved by a mathematics educator who completed master's and doctoral degrees at a Turkish University where the classes are taught in English. Then, the GTTM table construction process started. During this process, the document entitled "Explanatory notes for the mathematics framework" written by TIMSS researchers was used to clarify the meaning of each mathematics topic (Burstein et al., 1992). This document includes a brief description and a sample question for each 32 mathematics topic.

In order to improve the reliability of the study, the author and a mathematics educator separately coded a set of benchmarks for one grade level. For this purpose, the 4th grade was chosen since it has the maximum number of benchmarks. Fourth grade benchmarks constitute 17% of the total benchmarks. Before the analysis of fourth-grade benchmarks, the randomly selected benchmarks were coded together. The coding is done in the following way: If a topic is related to one or more benchmarks at a certain grade level, we entered 1 in the relevant GTTM table cell; if not then we entered 0. For example, whole number meaning is related to benchmarks at first grade, therefore we entered 1 in the cell at the intersection of the first grade column with the whole number meaning row. Coding was primarily conducted based on the benchmarks and related remarks. If the benchmarks and remarks are unclear, then the sample questions were examined. Coding some benchmarks together helped the two coders develop a common understanding about the GTTM table and improve the reliability of the study.

After developing a common understanding for GTTM topics, the coders worked separately and coded the 4th grade benchmarks using the GTTM table. Individual tables were used to calculate inter-coder reliability. The inter-coder reliability recommended by Miles and Huberman (1994) was used:

$$Reliability = \frac{Number\ of\ agreements}{Number\ of\ agreements + number\ of\ disagreements}$$

According to this formula, the number of agreements (27) was divided by the sum (32) of agreements and disagreements, and it yielded a reliability statistic of 0.84. According to Miles and Huberman (1994), this number is sufficient for reliability.

After individual coding, the coders compared their GTTM tables. They discussed about the discrepancies in their tables, shared the evidence for their codes until full agreement was reached. Since the reliability between coders was high and the author had prior experiences in constructing GTTM tables, the author coded the benchmarks at other grade levels. However, when there was any ambiguity about the codes, the author consulted the second coder and a joint decision was reached.

After constructing GTTM tables for Turkey's elementary and middle school mathematics standards, the standards were examined from three perspectives in light of previous studies (Hook et al., 2007; Schmidt et al., 2002; Schmidt et al., 1997) : 1. Number of topics at each grade level; 2. Topic repetition; 3. Organization of mathematics topics. As part of the analysis form the three perspectives, Turkey's GTTM table was compared with the A+ composite GTTM table constructed by Schmidt et al. (2002) and the CCSS for mathematics GTTM table constructed by Schmidt and Houang (2012).

Limitations

In this section, the limitations of the study will be discussed. The first limitation is that the GTTM topics do not cover all mathematics topics. TIMSS researchers chose 32 topics that would allow comparing curricula of different countries. For example, probability is not among the 32 topics. The second limitation is related to the scope of mathematical topics included in the GTTM table. Some topics are very comprehensive. For example, data representation and analysis is a very broad topic, it could be examined under several sub-topics. On the other hand, estimating quantity and size is not such a comprehensive topic. The third limitation is that the inferences made about standards might be affected from the order of the topics in the GTTM table. For example, the order of the topics in the GTTM table constructed by Schmidt et al. (2002) is different from the order of the topics in the GTTM table constructed by Schmidt and Houang (2012). Different sequencing of topics might have been preferred to support the researchers' inferences about the standards.

In spite of the aforesaid limitations, GTTM method has some advantages as well. For example, sometimes the number of benchmarks is used to represent the intensity or scope of standards. However, the number of benchmarks may be misleading; some benchmarks may contain multiple skills or concepts. In this sense, GTTM method provides more objective data about the scope of standards since it focuses on the number of topics rather than the number of benchmarks. GTTM method was used in this study since it allows conducting a comprehensive analysis about the scope and organization of mathematics in the standards and it has not been used in Turkey before.

Results

The findings from the analysis of Turkey's elementary and middle school mathematics standards using GTTM method and the comparison between Turkey's standards with other countries will be presented under 3 sub-sections: Number of topics at each grade level, topic repetition, and organization of mathematics topics.

Number of Topics at Each Grade Level

In the current study, first, the total number of topics at each grade level in Turkey's standards was determined. By compiling the findings of this study and previous studies (Schmidt & Houang, 2012; Schmidt et al., 1997), the total number topics at each grade level for CCSS for mathematics, standards of A+ countries, and Turkey's standards are presented in Table 1.

Table 1. Number of Topics at Each Grade Level by Country

Country	Grade Level							
	1	2	3	4	5	6	7	8
Singapore	5	6	6	14	19	20	30	21
Japan	8	10	18	20	26	21	14	19
Hong Kong	5	5	5	9	11	11	18	17
Belgium (Fl)	7	10	17	21	25	29	29	32
Czech Republic	3	12	13	15	21	21	17	19
Korea	4	11	15	17	22	22	26	18
CCSS	8	11	13	17	21	22	17	18
A+ Mean	5	9	12	16	21	21	22	21
Turkey	**9**	**12**	**15**	**17**	**18**	**21**	**17**	**18**
Turkey - CCSS Difference	**1**	**1**	**1**	**0**	**-3**	**-1**	**0**	**0**
Turkey - A+ Difference	**4**	**3**	**2**	**1**	**-3**	**0**	**-5**	**-3**

Table 1 shows that the biggest difference in the total number of topics between Turkey's standards and the A+ countries occurs at the 7th grade. In the 7th grade, Turkey has 17 topics while there are 22 topics in the A+ countries mean. The biggest difference between Turkey's standards and the CCSS for mathematics is at the 5th grade. At 5th grade, Turkey has 17 topics while the CCSS has 21 topics.

In the last two rows of Table 1, the number of topics at each grade level for Turkey's standards are compared with the A + mean and CCSS. The comparison reveals that overall Turkey's elementary school standards include more topics at each grade level than the A+ mean and CCSS, while Turkey's middle school standards include fewer topics. The average of the differences might offer a general idea about the total number of topics in Turkey's standards compared to other countries in Table 1. For elementary school standards the mean difference between Turkey's standards and CCSS is 0.75, while the mean for Turkey-A+ mean is 2.5. On average, the number of topics at each grade level in Turkey's elementary school standards is 1 more than the number of topics at each grade level in the CCSS. Similarly, on average the number of topics at each grade level in Turkey's standards is 2 or 3 less than the number of topics at each grade level in A+ mean. For middle school standards, the mean of the difference Turkey-CCSS is -1 and the mean of the difference Turkey-A+ mean is -2.75. On average, every year in Turkey's middle school standards, the number of total topics is 1 less compared to the CCSS and 3 less compared to the A+ mean.

Topic Repetition

The GTTM table for Turkey's elementary and middle school mathematics standards was generated and this table was used to determine topic repetition. Table 2 shows the GTTM table for Turkey's standards. The second to last column of Table 2 presents how many school years a topic stays in Turkey's standards. Similarly, topic repetition for the CCSS for mathematics is given in the last column of Table 2. A+ composite is not included in this section since it does not represent a complete curriculum. Rather, A+ composite represents a core curriculum. The A+ composite GTTM table was developed by using the mathematics topics intended by at least two-thirds of A+ countries (Schmidt et al., 2002). Turkey's standards are compared with A+ composite in the next section.

Table 2 shows that the topics that are included at every grade level (TR=8) in Turkey's standards are data representation and analysis, and 3-D geometry. Measurement estimation and errors, and constructions with straightedge and compass are not included in Turkey's standards. The GTTM topics found in the CCSS at all grade levels are measurement units, data representation and analysis, and polygons and circles. Estimating quantity and size is not contained in the CCSS.

Table 2. The GTTM Table for Turkey's Elementary and Middle School Mathematics Standards

GTTM Topic	1	2	3	4	5	6	7	8	TR	CCSS TR
Whole Number Meaning	♦	♦	♦	♦	♦				5	5
Whole Number Operations	♦	♦	♦	♦	♦	♦			6	5
Properties of Whole Number Operations	♦	♦		♦		♦			4	6
Common Fractions	♦	♦	♦	♦	♦	♦			6	6
Measurement Units	♦	♦	♦	♦	♦	♦			6	8
Polygons & Circles		♦	♦	♦	♦	♦	♦	♦	7	8
Data Representation & Analysis	♦	♦	♦	♦	♦	♦	♦	♦	8	8
3-D Geometry	♦	♦	♦	♦	♦	♦	♦	♦	8	6
Estimating Quantity & Size	♦	♦	♦	♦	♦	♦		♦	7	0
Measurement Estimation & Errors									0	2
Number Theory			♦		♦	♦		♦	4	4
2-D Geometry: Basics			♦	♦	♦	♦	♦	♦	6	6
Rounding & Significant Figures		♦	♦	♦		♦			4	3
Relationship of Common & Decimal Fractions			♦	♦	♦	♦			4	4
Estimating Computations		♦	♦	♦	♦	♦	♦	♦	7	5
Perimeter, Area & Volume			♦	♦	♦	♦	♦	♦	6	6
Equations & Formulas						♦	♦	♦	3	6
Decimal Fractions				♦	♦	♦			3	3
Patterns, Relations & Functions				♦	♦	♦	♦	♦	5	5
Geometry: Transformations	♦	♦	♦	♦			♦	♦	6	4
Properties of Common & Decimal Fractions					♦				1	2
Exponents & Orders of Magnitude								♦	1	2
2-D Coordinate Geometry							♦	♦	2	4
Exponents, Roots & Radicals					♦	♦	♦	♦	4	3
Percentages					♦		♦		2	2
Negative Numbers, Integers & Their Properties						♦	♦		2	2
Proportionality Concepts						♦	♦		2	3
Proportionality Problems						♦	♦	♦	3	3
Rational Numbers & Their Properties							♦	♦	2	3
Constructions w/ Straightedge & Compass									0	1
Congruence & Similarity							♦	♦	2	1
Slope & Trigonometry								♦	1	1

♦ : Turkey's standards include the topic at the grade level.
TR: Topic repetition.

One of the analyses carried out about topic repetition was calculating the mean topic repetition for each standard. The mean topic repetition for both Turkey's standards and the CCSS for mathematics is approximately 3.97 (127/32) years. In other words, a topic remains in both standards for about 4 years. Another analysis on topic repetition was calculating the difference between the last two columns in Table 2 in order to further compare Turkey's standards with the CCSS. The biggest difference was 7 at estimating quantity and size, and the second largest difference was 3 at equations and formulas.

The Organization of Mathematics Topics

Table 3 was generated to compare the organization of mathematics topics in Turkey's standards with the A+ composite, and Table 4 was generated to compare the organization of mathematics topics in Turkey's standards with the CCSS. Original GTTM tables were used to be compatible with the international literature. Accordingly, the sequence of topics in Table 3 is different from the sequence in other tables. When the Tables 2, 3 and 4 were analyzed in terms of the organization of mathematics over the years, similarities and differences between Turkey's standards and the A+ composite and between Turkey's standards and the CCSS have been found.

Table 3. GTTM Analysis for Turkey's Standards and the A+ Composite

GTTM Topic	1	2	3	4	5	6	7	8
Whole Number Meaning	♦■	♦■	♦■	♦■	♦■			
Whole Number Operations	♦■	♦■	♦■	♦■	♦■	♦		
Measurement Units	♦■	♦■	♦■	♦■	♦■	♦■	■	
Common Fractions	♦	♦	♦■	♦■	♦■	♦■		
Equations & Formulas			■	■	■	♦■	♦■	♦■
Data Representation & Analysis	♦	♦	♦■	♦■	♦■	♦■	♦	♦■
2-D Geometry: Basics			♦■	♦■	♦■	♦■	♦■	♦■
Polygons & Circles		♦	♦	♦■	♦■	♦■	♦■	♦■
Perimeter, Area & Volume			♦	♦■	♦■	♦■	♦■	♦■
Rounding & Significant Figures		♦	♦	♦■	■	♦		
Estimating Computations		♦	♦	♦■	♦■	♦■	♦	♦
Properties of Whole Number Operations	♦	♦		♦■	■	♦		
Estimating Quantity & Size	♦	♦	♦	♦■	♦■	♦		♦
Decimal Fractions				♦■	♦■	♦■		
Relationship of Common & Decimal Fractions			♦■	♦■	♦■	♦■		
Properties of Common & Decimal Fractions					♦■	■		
Percentages					♦■	■	♦■	■
Proportionality Concepts					■	♦■	♦■	■
Proportionality Problems					■	♦■	♦■	♦■
2-D Coordinate Geometry					■	■	♦■	♦■
Geometry: Transformations	♦	♦	♦	♦		■	♦■	♦■
Negative Numbers, Integers & Their Properties						♦■	♦■	
Number Theory			♦		♦	♦	■	♦■
Exponents, Roots & Radicals					♦	♦	♦■	♦■
Exponents & Orders of Magnitude							■	♦■
Measurement Estimation & Errors							■	
Constructions w/ Straightedge & Compass							■	■
3-D Geometry	♦	♦	♦	♦	♦	♦	♦■	♦■
Congruence & Similarity							♦	♦■
Rational Numbers & Their Properties							♦	♦■
Patterns, Relations & Functions				♦	♦	♦	♦	♦■
Slope & Trigonometry								♦■

♦ : Turkey's standards include the topic at the grade level.
■ : A+ composite include the topic at the grade level.

Previous research revealed that mathematics is organized in three tiers in both the A+ composite and CCSS for mathematics (Schmidt & Houang, 2012; Schmidt et al., 2002). Tables 2, 3 and 4 indicate that mathematics is also organized in three tiers in Turkey's standards. Similar to the structure of mathematics in the A+ composite and CCSS, the first tier in Turkey's standards is covered in grades 1 through 4, the second tier is covered in grades 5 and 6, and the third tier is covered in grades 7 and 8. The first tier focuses on whole numbers and geometry but also includes fractions, decimals, rounding, measurement units, and estimation. The second tier consists of whole numbers, fractions, decimals, and more advanced topics such as proportions, percentages, and exponents. The third tier contains advanced number topics such as rational numbers and radicals, algebra topics such as slope, equations and functions, and advanced geometry topics such as congruence and similarity. With regard to the organization of mathematics in Turkey's standards, grades 5 and 6 seem to serve as a bridge for transitioning from the first tier to the third tier. This aspect of the mathematical structure observed in Turkey's standards is similar to the mathematical structure observed in the A+ composite and the CCSS for mathematics.

Table 4. GTTM Analysis for Turkey's Standards and the CCSS for Mathematics

GTTM Topic	1	2	3	4	5	6	7	8
Whole Number Meaning	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■			
Whole Number Operations	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦		
Properties of Whole Number Operations	♦ ■	♦ ■	■	♦ ■	■	♦ ■		
Common Fractions	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■		
Measurement Units	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	■	■
Polygons & Circles	■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■
Data Representation & Analysis	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■
3-D Geometry	♦ ■	♦ ■	♦	♦	♦ ■	♦ ■	♦ ■	♦ ■
Estimating Quantity & Size	♦	♦	♦	♦	♦	♦		♦
Measurement Estimation & Errors		■	■					
Number Theory		■	♦	■	♦ ■	♦ ■		♦
2-D Geometry: Basics		■	♦	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■
Rounding & Significant Figures		♦	♦ ■	♦ ■	■	♦		
Relationship of Common & Decimal Fractions			♦ ■	♦ ■	♦ ■	♦ ■		
Estimating Computations		♦	♦ ■	♦ ■	♦ ■	♦	♦ ■	♦ ■
Perimeter, Area & Volume			♦ ■	♦ ■	♦ ■	♦ ■	♦ ■	♦ ■
Equations & Formulas			■	■	■	♦ ■	♦ ■	♦ ■
Decimal Fractions				♦ ■	♦ ■	♦ ■		
Patterns, Relations & Functions				♦ ■	♦ ■	♦ ■	♦ ■	♦ ■
Geometry: Transformations	♦	♦	♦	♦ ■		■	♦ ■	♦ ■
Properties of Common & Decimal Fractions					♦ ■	■		
Exponents & Orders of Magnitude					■			♦ ■
2-D Coordinate Geometry					■	■	♦ ■	♦ ■
Exponents, Roots & Radicals					♦ ■	♦ ■	♦	♦ ■
Percentages					♦	■	♦ ■	
Negative Numbers, Integers & Their Properties						♦ ■	♦ ■	
Proportionality Concepts						♦ ■	♦ ■	■
Proportionality Problems						♦ ■	♦ ■	♦ ■
Rational Numbers & Their Properties						■	♦ ■	♦ ■
Constructions w/ Straightedge & Compass							■	
Congruence & Similarity							♦	♦ ■
Slope & Trigonometry								♦ ■

♦ : Turkey's standards include the topic at the grade level.

■ : CCSS include the topic at the grade level.

There are also differences between Turkey's standards and the other two standards, the A+ composite and the CCSS for mathematics. One of the differences is that measurement estimation and errors, and constructions with straightedge and compass are not contained in Turkey's standards, while these topics are included both in the A+ composite and the CCSS. Of these topics, about constructions with straightedge and compass it should be noted that there are benchmarks related to geometric constructions in Turkey's standards. However, these benchmarks could be achieved by paper folding or using graph paper. The use of straightedge and compass is not particularly required.

Another difference between Turkey's standards and the other two standards is related to topics that are contained in all three tiers. According to Schmidt et al. (2002), such topics in the A+ composite support the continuity of the standards. The A+ composite includes measurement units, polygons and circles, data representation and analysis, 2D geometry basics, perimeter, area and volume, and equations and formulas across all three tiers. In addition to these topics, CCSS contains 3D geometry, estimating computations, patterns, relationships and functions, and geometric transformations across all three tiers. Measurement units, and equations and formulas are the two topics that are contained in all three tiers in the A+ composite and the CCSS, but not contained in all three tiers in Turkey's standards. Geometric transformations are included in the CCSS program across all three tiers, while Turkey's standards contain this topic in tiers 1 and 3. Number theory is the topic that is found across all three tiers in Turkey's standards, but not in the A+ composite and the CCSS.

Discussion, Conclusion and Suggestions

Curriculum is the basic material that reflects the educational policy of the countries (Schmidt et al., 1997). Therefore, development or revision of the mathematics curriculum is an inevitable part of the efforts carried out to improve mathematics education in a country. The study presented in this article aimed to contribute to curriculum development studies by using the GTTM method for analyzing mathematics standards. In the study, Turkey's current elementary and middle school mathematics standards were examined using the GTTM method. Turkey's GTTM table was compared with the A + composite GTTM table and with the CCSS GTTM table from three perspectives: Number of topics at each grade level, topic repetition, organization of mathematics topics.

First, the total number of topics at each grade level was determined. Compared to A+ countries' standards and the CCSS for mathematics, Turkey's elementary school mathematics standards include more topics, while Turkey's middle school mathematics standards include fewer topics. In their study of the states' standards, Schmidt et al. (2002) found that the states had more topics in their standards than the A+ composite. Schmidt et al. (2002) argued that intending to teach too many topics at a grade level avoid teaching the subject matter in depth and criticized this structure of the states' standards with the phrase "a mile wide and an inch deep" (p. 3). Decreasing the number of topics at a grade level provides teachers with more time to teach the subject matter conceptually as well as allowing time to carry out projects and make connections with other disciplines (Hook et al., 2007; Schoen et al., 2011; Schmidt et al., 2002). Undoubtedly, the number of topics alone is not a sufficient criterion for evaluating the standards. One of the many other factors that need to be examined is whether the standards are built on research findings and reflect the complexity of the discipline. When the standards include less number of topics, but focus on important ideas of the discipline and relate other topics to the core topics, such a structure is considered as an indicator of high quality standards (Cobb & Jackson, 2011; NCTM, 2006). It could be ideal to balance the number of topics so that the standards represent the complex structure of mathematics and support students' conceptual understanding.

Secondly, the study examined topic repetition within the standards. According to Schmidt et al. (2002), a coherent curriculum is not highly repetitive. For example, a topic stays in the A+ composite for an average span of three years. Average topic duration is 3.97 years for both the CCSS and Turkey's standards. These figures indicate that Turkey's standards are not highly repetitive. However, the content of the benchmarks should be examined to find out if the same expectations are repeating over the years.

Third, the organization of mathematics in Turkey’s standards was compared with the organization of mathematics in the A+ composite and the CCSS. Similar to the structure of A+ composite and the CCSS, Turkey’s standards organize mathematics in three tiers. The first tier focuses on arithmetic and geometry. Based on the recommendation that elementary school mathematics should focus on whole number meaning, whole number operations, and fractions, and include some measurement and geometry (National Mathematics Advisory Panel, 2008), Turkey's standards are well organized at tier-one. While the second tier in Turkey’s standards serve as a bridge between the first and third tiers, the third tier includes more advanced number, geometry, and algebra topics. Seventh and 8th grade mathematics should focus on algebra, proportions, and congruence and similarity (NCTM, 2006; National Mathematics Advisory Panel, 2008). Accordingly, the third tier in Turkey's standards consists of important mathematical topics.

The analysis of the organization of mathematics in the standards identified the topics that are contained in the A+ composite and the CCSS, but not contained at any grade level in Turkey’s standards. These topics are measurement estimation and errors, and constructions with straightedge and compass. Measurement estimation and errors is an important topic in statistics. In fact, one of the fundamental principles of measurement is that measurement is estimation (Yıldırım, 2010). Constructions with straightedge and compass are important processes in Euclidean geometry. Thus the excluded topics may enrich the mathematics in Turkey’s standards. From another point of view, if Turkey’s standards lack mathematics topics that other countries’ standards include, it could negatively affect Turkey’s success in international exams.

As part of the analysis on the organization of mathematics in the standards, the topics that are included across all three tiers have been identified. These topics may support the continuity of the standards (Schmidt et al., 2002). The topic found in all tiers of Turkey's standards, but not in all tiers of the A+ composite and the CCSS is number theory. This topic stays in Turkey’s standards for 4 years. Since there is not excessive repetition and the topic is significant as it investigates relationships between numbers, this finding could be considered as a positive aspect of Turkey’s standards.

The topics found across all three tiers in the A+ composite or the CCSS but not in Turkey’s standards are measurement units, equations and formulas, and geometric transformations. With respect to the measurement units, the CCSS includes compound units in relation to proportionality at tier-three. Similar benchmarks in Turkey's standards are found in the 6th grade. Distribution of the benchmarks about measurement units in Turkey’s standards can be evaluated in future standard development endeavors. Equations and formulas are related to algebra. Algebra is becoming increasingly important, and it is one of the fundamental topics for students to learn more advanced mathematics (National Mathematics Advisory Panel, 2008; Kaput, 2000). Despite the importance of algebra, equations and formulas enters into Turkey’s standards at the 6th grade. Two-dimensional coordinate geometry, another topic related to algebra, is included in Turkey’s standards at the 7th grade for the first time. Geometric transformations stay in Turkey's elementary school standards across all years, and then disappear at grades 5 and 6. Considering the finding that the total number of topics in elementary school standards is more than the number of topics in the A+ composite and the CCSS, geometric transformations may be removed from some elementary school grades and added to the 5th or 6th grade.

Analyzing Turkey’s standards with the GTTM method and comparing it with the A+ composite and the CCSS from three perspectives has provided important information about the standards. The most significant suggestion of the study is using the GTTM method in future standard development endeavors. Surely, standard analysis studies should include other aspects of standards such as the cognitive level of the benchmarks, contents of the benchmarks, or the significance of mathematical processes in the benchmarks. GTTM is one of several methods, but as shown in this study it provides significant observations about the standards. Based on the GTTM analysis conducted in this study, the following recommendations can be made for Turkey's elementary and middle school mathematics standards.

- The total number of topics may be balanced for the elementary and middle school standards.
- In the case of topics repetition, the content of benchmarks may be examined to avoid teaching the same contents over the years.
- The topics that are not contained in Turkey's current standards, measurement estimation and errors, and constructions with straightedge and compass, may be included in the standards in future revisions.
- Algebra topics may be included in the standards at earlier grade levels.
- Geometric transformations may be removed from some grade levels in the elementary school standards, and may be added to 5th or 6th grade level.

The findings of this study revealed several strengths of Turkey's standards. The study also made some suggestions about how to revise the standards. Future studies might examine the scope and organization of a particular strand of mathematics in different standards. In that case, the mathematical topics in the GTTM table might be modified to include more subtopics. In addition, similar studies can be conducted for other disciplines. TIMSS researchers have developed a similar method for science (Schmidt, who Raiz, Britton, Bianchi & Wolfe, 1997). Science researchers might compare science and technology standards in different countries by using this method.

References

Aksu, H.H. (2008). Öğretmenlerin yeni ilköğretim matematik programına ilişkin görüşleri. *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi, 8*(1), 1-10.

Bukova-Güzel, E. ve Alkan, H. (2005). Yeniden yapılandırılan ilköğretim programı pilot uygulamasının değerlendirilmesi. *Kuram ve Uygulamada Eğitim Bilimleri Dergisi, 5*(2), 385-420.

Burstein, L., Schmidt, W. H., McKnight, C., Wiley, D., Raizen, S., Wolfe R., & Robitaille, D. (1992). *Explanatory notes for the mathematics framework* (Research Rep. Series No. 41). East Lansing, Michigan: TIMSS.

Cobb, P. & Jackson, K. (2011). Assessing the quality of the common core state standards for mathematics. *Educational Researcher, 40*(4), 183-185.

Delil, A. ve Güleş, S. (2007). Yeni ilköğretim 6. sınıf matematik programındaki geometri ve ölçme öğrenme alanlarının yapılandırmacı öğrenme yaklaşımı açısından değerlendirilmesi. *Uludağ Üniversitesi Eğitim Fakültesi Dergisi, 20*(1), 35–48.

Halat, E. (2007). Yeni ilköğretim matematik programı (1-5) ile ilgili sınıf öğretmenlerinin görüşleri. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi, 9*(1), 63-88.

Hook, W., Bishop, W., & Hook, J. (2007). A quality math curriculum in support of effective teaching for elementary schools. *Educational Studies in Mathematics*, *65*(2), 125-148.

Kaput, J. J. (2000). *Transforming algebra from an engine of inequity to an engine of mathematical power by 'algebrafying' the K-12 curriculum*. Dartmouth, MA: National Center for Improving Student Learning and Achievement in Mathematics and Science.

Kay, O. ve Halat, E. (2009). Mesleki durum değişkenine bağlı olarak yeni (2005) ilköğretim matematik öğretim programının veli görüşleri doğrultusunda değerlendirmesi. *Kastamonu Eğitim Dergisi, 17*(2), 581-596.

NCTM (2000). *Principles and standards for school mathematics*. Retrieved April 5 2005, at URL: http://www.nctm.org/ standards/default.aspx?id=58

NCTM (2006). *Curriculum focal points for prekindergarten through grade 8 mathematics: A quest for coherence*. Reston,VA.

National Governors Association Center for Best Practices, Council of Chief State School Officers (2010). *Common core state standards for mathematics*. [Online] Retrieved January 2 2012, at URL: http://www.corestandards.org/assets/CCSSI_Math%20Standards.pdf

National Mathematics Advisory Panel (2008). *Foundations for success: The final report of the National Mathematics Advisory Panel*, Washington, DC: U.S. Department of Education.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*, second edition. Thousand Oaks, CA: Sage Publications.

MoNE (2009). *İlköğretim matematik dersi 1-5. sınıflar öğretim programı ve kılavuzu*. Retrieved January 3 2012, http://ttkb.meb.gov.tr/program.aspx?islem=1&kno=32.

MoNE (2013). *Ortaokul matematik dersi öğretim programı*. Retrieved July 3 2014, http://ttkb.meb.gov.tr/ www/guncellenen-ogretim-programlari/icerik/151.

OECD (2010). PISA 2009 *Results: Executive summary*. [Online] Retrieved May 25 2012, http://dx.doi.org/10.1787/888932343342

Olkun, S. (2005). *Matematik öğretim programı inceleme raporu, Yeni öğretim programlarını inceleme ve değerlendirme raporu* (ss: 95-111). Retrieved April 14 2012, http://ilkogretim-online.org.tr/vol5say1/yenimufredat_raporu[1].pdf.

Schmidt, W. H. & Houang, R. T. (2012). Curricular coherence and the common core state standards for mathematics. *Educational Researcher, 41*(8), 294–308.

Schmidt, W. H., Houang, R., & Cogan, L. (2002). A coherent curriculum: The case of mathematics. *American Educator, 26*, 1-18.

Schmidt, W.H., McKnight, C.C., Valverde, G.A., Wolf, R.G., Britton, E.D., Bianchi, L.J., & Houang, R.T. (1997). *Many visions, many aims, volume 1: A cross-national investigation of curricular intentions in school mathematics*. Dordrecht, The Netherlands: Kluwer.

Schmidt, W.H., Raizen, S., Britton, E.D., Bianchi, L.J., Wolfe, R.G. (1997) *Many visions, many aims, volume 2: A cross-national investigation of curricular intentions in school science*. Dordrecht, Netherlands: Kluwer.

Schmidt, W.H., Wang, H.C., & McKnight, C.C. (2005). Curriculum coherence: An examination of US mathematics and science content standards from an international perspective. *Journal of Curriculum Studies, 37*(5), 525-559.

Schoen, R., Erbilgin, E., & Haciomeroglu, S. E. (2011). Analyzing the Next Generation Sunshine State Standards for mathematics: Is the State Curriculum still a mile wide and an inch deep? *Dimensions in Mathematics, 31*(1), 30-39.

TTKB (2005). *İlköğretim Programları Genel Yaklaşım-Yeni İlköğretim Programları ve Yeni Yaklaşımlar.* Retrieved July 13 2009, http://ttkb.meb.gov.tr/ogretmen/modules.php?name=Downloads&od_op=vievdowload&cid=48.

Umay, A., Akkuş, O., & Paksu, A. (2006). An investigation of 1-5 grades mathematics curriculum by considering NCTM principles and standards. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, 31, 198-211.

Yıldırım, B. (2010). Ölçme. B. Akman (Ed.) Okul Öncesi Matematik Eğitimi (s. 148-157). Ankara: Pegem Akademi.

Zembat, İ. Ö. (2010). *Ölçme, Temel Bileşenleri ve Sık Karşılaşılan Kavram Yanılgıları*, E. Bingölbali ve M. F. Özmantar (Ed.) İlköğretimde Karşılaşılan Matematiksel Zorluklar ve Çözüm Önerileri (ss 127-154). Ankara: Pegem Akademi.