

## **A comparative analysis of numbers and biology content domains between Turkey and the USA**

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This study aimed to compare Mathematics and Science programs focusing on TIMSS content domains of Numbers and Biology that produced the largest achievement gap among students from Turkey and the USA. Specifically, it utilized the content analysis method within Turkish and New York State (NYS) frameworks. The procedures of study included matching the behaviors for the content domains of Numbers and Biology, as defined in the TIMSS 2007 framework, with the teaching program and guidebook for Mathematics courses (grades 6 through 8) in Turkey and NYS learning standards and core curriculum for Science and Mathematics for the U.S. Results of the study indicated differences between Turkey and NYS in terms of existence and distribution of and emphasis on TIMSS content domains of Numbers and Biology across the grade levels.

**Keywords:** numbers, biology, TIMSS

### **Introduction**

Cross-system studies have attracted considerable interest from researchers in education. Postlethwaite (1988) states that cross-system comparative studies in education aimed to identify occurrences in different countries that potentially contribute to improvements in their education systems and outcomes; to describe and interpret reasons for the presence of similarities and differences between education systems; to assess relative effects of variables latent in educational results; and to demonstrate general principles concerning educational effects.

Some comparative studies have presented an interpretation of TIMSS results for Turkey and other countries. Ozturk and Ucar (2010) compared Chinese Taipei, among the top five achievers in Mathematics and Science, and Turkey, below the international average in both. In their study, several of the reasons that contributed to students' low academic performance included socio-economic level, parents' educational level, quality of teachers and schools, and curricul-

lum coverage (Ozturk & Ucar, 2010). Similarly, in the TIMSS Turkey report, among the important factors affecting countries' achievement were socio-economics, parents' education level, and quality of schooling. Another criticism offered by TIMSS was a language problem. The original test language is English and other countries present the test after it has been translated into their mother language. These translations suffer from mistakes, which, in turn, cause unsuccessful results for students who are not native English (Dempster & Reddy, 2007).

### **A Review of TIMSS**

The Third International Mathematics and Science Study (TIMSS) is a series of studies conducted by the International Association for the Evaluation of Educational Achievement (IEA). IEA has administered more than 25 studies of cross-national achievement in the curricular areas of Mathematics, Science, Language, Civics, and Reading since 1959. The Secretariat of IEA is located in Amsterdam, The Netherlands, while the center of data analysis is in Hamburg, Germany. IEA focuses their research on curricula and what students learn in class during school time. Early key studies conducted by IEA were the First International Science Study (FISS) in 1970-71; the Second International Science Study (SISS) in 1983-84 were conducted by IEA; and the First and Second International Mathematics Studies (FIMS and SIMS) were conducted in 1964 and 1980-82, respectively. The largest and most complex IEA studies were conducted as TIMSS in 1995, 1999, 2003, and 2007, including both Mathematics and Science at grades 4 and 8 and the final year of secondary school (ISC, 2008). TIMSS aimed to compare students' achievements in Science and Mathematics on a regular four-year cycle across different countries.

For TIMSS 2007, data were collected from 59 different countries in more than 30 different languages; 48 countries participated at grade 8 in 2007, while 36 participated at grade 4, for a total of approximately 425,000 students. This study also included thousands of administrators from the approximately 15,000 schools involved. Four content dimensions were covered in the TIMSS Science tests given to the primary-school (grade 4) students: Earth Science, Life Science, Physical Science, and Environmental Issues and the Nature of Science. About one-fourth of the questions were in free-response format requiring students to generate and write their answers. These types of questions, some of which required extended responses, were selected for approximately one-third of the testing time (ISC, 2008).

### **Developing the Science and Mathematics Tests**

The TIMSS test was developed in 2007 by a group of Science and Mathematics Educators with input from the TIMSS National Research Coordinators. This process of designing the test involved many individuals and expert groups from more than 60 countries (ISC, 2005).

#### *The Framework of the TIMSS 2007 Mathematics Assessments*

The TIMSS 2007 Mathematics assessment framework for grades 4 and 8 included two domains: content and cognitive. The content domain for Mathematics included Number, Algebra, Geometry, and Data and Chance, while the cognitive domain included Knowing, Applying, and Reasoning.

In regard to the Mathematics assessment, the analysis of the current study emphasized the content domain Number. In grade 4, the content domain Number included: whole numbers; fraction and decimals; number sentences; and patterns and relationships. In grade 8, the content domain Number included: whole numbers; fraction and decimals; integers; and ratio, proportion and percent. Table 1 presents the target percentages of the TIMSS 2007 Mathematics assessment

devoted to each content domain in grades 4 and 8. Particularly, it shows that the content domain Number has more percentage coverage in grade 4 than in grade 8.

Table 1. The Percentages of Content of Mathematics Test

	Content Domain	Percentage
Grade 4	Number	50%
	Geometric Shapes and Measures	35%
	Data Display	15%
Grade 8	Number	30%
	Algebra	30%
	Geometry	20%
	Data and Change	20%

Adapted from IEA (2005)

*The Framework of the TIMSS 2007 Science Assessments*

Like the TIMSS 2007 Mathematics assessment framework, the TIMSS 2007 Science assessment included two main domains: domain and cognitive. The content domain (subject matter) for Science included Biology, Chemistry, Physics, and Earth Science in grade 8, while the cognitive domain included Knowing, Applying, and Reasoning (IEA, 2005).

In regard to the Science assessment, the analysis of the current study emphasized the content domain Biology. In grade 4, the content domain Biology included: characteristics and life processes of living things; life cycles, reproduction, and heredity; interaction with the environment; ecosystems; and human health. In grade 8, the content domain Biology included cells and their functions; and diversity, adaptation and natural selection; as well as the five topics covered in grade 4. Table 2 presents the target percentages of the TIMSS 2007 Science assessment devoted to each content domain in grades 4 and 8. Particularly, it shows that the content domain Biology has more percentage coverage in grade 4 (under Life Science) than in grade 8.

Table 2. The Percentages of Content and Cognitive Domains of Science Test

	Content Domain	Percentage
Grade 4	Life Science	45%
	Physical Science	35%
	Earth Science	20%
Grade 8	Biology	35%
	Chemistry	20%
	Physics	25%
	Earth Science	20%

Adapted from IEA (2005)

The purpose of this study is to compare Turkish and the U.S. Mathematics (Numbers) and Science (Biology) frameworks in terms of behaviors defined in the TIMSS framework. The content domains of Numbers and Biology were chosen as a focus of comparison in Mathematics and Science, respectively, because these domains included more items than the other domains covered in mathematics and science assessments in TIMSS 2007, and among the all the achieve-

ment gap between students from two countries was found to be the largest for these domains. Towards this aim the research problems were;

- 1) What were the similarities and differences of the distribution of the behaviors of TIMSS content domain number in the mathematics frameworks in NYS and Turkey?
- 2) What were the similarities and differences of the distribution of the behaviors of TIMSS content domain biology in the science frameworks in NYS and Turkey?

### **Methodology**

The current study utilized the content analysis method to examine the Turkish and the New York State (NYS) frameworks. Content analysis is defined as “a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the context of their use” (Krippendorff, 2004, p. 18) and as “systematic assignments of communication content to categories according to rules and the analysis of relationships involving those categories using statistical methods” (Riffe, Lacy, & Fico, 2005, p. 3). Among the advantages of content analysis are that: the messages and data gathered from documents are not being affected by the researcher’s influence, subject or research setting (Fraenkel & Wallen, 2008; Krippendorff, 2004; Riffe, Lacy, & Fico, 2005); the source of the data is preserved due to the unstructured analysis procedure of content analysis (Krippendorff, 2004); content analysis does not involve problems related to participants because no participants are required (Sarantakos, 2005); and it is independent of time and space-documents can be collected from the past and/or the present (Fraenkel & Wallen, 2008).

The content analysis method was used to analyze the inclusion of behaviors for content domains Numbers and Biology (as defined in the TIMSS 2007 Mathematics and Science framework) in the NYS learning framework and the Turkish elementary Mathematics teaching program. To draw conclusions from the items enumerated or outlined in Krippendorff’s definition, the researchers systematically assigned content to predefined categories and analyzed it statistically.

#### *Data Collection Tools*

Three data collection tools were utilized in the current study: 1) *Grades 1-5 Teaching Program and Guidebook for Mathematics Course* (MONE, 2009a), an official Mathematics teaching framework for primary schools (grades 1 through 5) in Turkey; 2) *Grades 6-8 Teaching Program and Guidebook for Mathematics Course* (MONE, 2009b), an official Mathematics teaching program for primary schools (grades 6 through 8) in Turkey; and 3) *NYS Learning Standards and Core Curriculum for Science and Mathematics*, an official document prepared by the NYS Department of Education. The first and second frameworks are approved by the Turkish Ministry of National Education (MONE) and are required by the law to be adopted by all schools in Turkey. The NYS learning standards and core curriculum for Science and Mathematics include the NYS Mathematics and Science frameworks and all public schools in NYS are required to follow them.

#### *Procedures*

To interpret the NYS and Turkish programs based on TIMSS behaviors, a panel of four experts (two from Mathematics Education and two from Science Education) was convened. The experts from each domain had familiarity and experience with both frameworks. The panel met over a two-day period to review the framework and classify the Turkish and NYS Number and Biology content based on the behaviors defined in the TIMSS framework.

This meeting provided an overview of the TIMSS framework and outlined the procedures for reviewing items. During the opening plenary session, the expert panel members also had an opportunity to review, classify, and discuss several practice items in order to establish a common understanding of the classification procedures.

According to the sub-domains by Mullis and colleagues (2008) in the *TIMSS Mathematics Framework*, the content domain Number was categorized into: whole numbers; fractions and decimals; integers; and ratio, proportion and percent; while the content domain Biology was categorized into: characteristics and life processes of living things; characteristics, classification, and life processes of organisms; cells and their functions, life cycles, reproduction, and heredity; interaction with the environment; diversity, adaptation, and natural selection, ecosystems; and human health. Fraenkel and Wallen (2008) maintain that the categories used in content analysis should be clear and enable other researchers to have the same results when they examine the same data with those categories. In this study, the researchers did not develop the categories; rather, they were adapted from the TIMSS 2007 Mathematics framework (Mullis et al., 2008).

All Biology and Numbers content in the above-mentioned programs were coded according to the TIMSS 2007 framework. To work out the coding procedure, a panel of coders worked independently to code each objective stated in the TIMSS Numbers and Biology content domains in the programs. For example, *demonstrating knowledge of place value and of the four operations*, the first objective for the sub domain of whole numbers, was coded in to the grades 4, 5 and 6 in Turkish program while it was coded as the grades 4 and 5 for the NY State program. Based on Miles and Huberman's (1994) reliability formula, the initial inter-coder agreement rate was found to be 93%. The content on which the coders did not agree was then discussed until they reached an agreement.

#### *Data Analysis*

The panel of experts determined the frequency of content domains broken down by grade level. Two experts were from the field of mathematics education, and the other two experts were from the field of science and technology education. All experts hold a Ph.D. degree in their area and had numerous articles relating comparative and curricular studies. The interpretation of the analyses is descriptive in nature.

### **Results**

The results of the study included a comparison of the content domains Numbers and Biology between Turkey and NYS.

#### *Comparison of Content Domain Number*

Table 3 presents the distribution of behaviors of the TIMSS content domain Number in Turkish and NYS Mathematics frameworks for descriptions of all behaviors defined for the content domain Number.

In both countries, whole numbers is introduced to students in grade 1. *Demonstrating knowledge of place value and of the four operations* (WN1) is included in grades 4 and 5 in both Turkey and NYS, while this topic is also covered in grade 6 in Turkey. Turkish students are introduced to the whole number behaviors of *finding and using multiples or factors of numbers, reading scales, and identifying prime numbers* (WN2) and *using the principles of commutativity, associativity, and distributivity* (WN3) in grade 5; by contrast, NYS students encounter the former behavior (WN2) in grades 5 through 7 and the latter (WN3) in grade 6. Like grades 7 and 8

students in NYS, grade 8 students in Turkey are required to *evaluate powers of numbers and square roots of perfect squares to 144* (WN4). *Solving problems by computing, estimating, or approximating* (WN5) is introduced to NYS students from grades 4 to 8 and to Turkish students in grades 5, 6, and 8.

Table 3. Distribution of Behaviors of TIMSS Content Domain Number in NYS and Turkish Mathematics frameworks

Subdomains	Behaviors	Turkey								NYS							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Whole numbers	WN1				X	x	x						x	x			
	WN2					x								x	x	x	
	WN3					x									x		
	WN4															x	x
	WN5					x	x		x					x	x	x	x
Fractions and decimals	FD1				X	x	x						x	x			
	FD2				X	x	x						x				
	FD3					x	x						x	x	x		
	FD4			x	X								x	x			
	FD5							x						x	x		
	FD6								x					x			
	FD7					x	x							x	x	x	x
Integers	I1							x	x						x	x	
	I2								x							x	x
Ratio, proportion and percent	RPP1					x								x	x		
	RPP2					x	x							x	x		
	RPP3					x	x								x		
	RPP4					x	x							x	x	x	x

Fractions and decimals are introduced to Turkish students in grade 2 but to NYS students in grade 3. The behaviors of *comparing and ordering fractions and decimals* (FD1) and *demonstrating knowledge of place value for decimals* (FD2) are taught in grades 4 through 8 in Turkey, while FD1 is taught in grades 4 and 5 and FD2 in grade 4 in NYS. Turkish students are required to *represent decimals and fractions and operations with decimals and fractions using models (e.g., number lines) as well as to identify and use such representations* (FD3) in grades 5 and 6, whereas NYS students encounter the same behavior in grades 4, 5, and 6. *Recognizing and writing equivalent fractions* (FD4) is introduced to Turkish students in grades 3 and 4, and to NYS students in grades 4 and 5. *Converting between fractions and decimals* (FD5) and *computing with fractions and decimals* (FD6) behaviors are included in grade 6 in Turkey; however, FD5 is included in grades 5 and 6 and FD6 in grade 5 in NYS. Turkish students are instructed with the behavior of *solving problems by computing, estimating, and approximating* (FD7) in grade 5 and 6, while NYS students encounter FD7 in grades 4 through 7.

The sub-domain of integers is included in both Turkish and NYS Mathematics programs for the first time in grade 6. *Representing, comparing, ordering, and computing with integers* (I1) appears in grades 6 and 8 in both Turkey and NYS, while *solving problems using integers* (I2) appears in grade 7 in Turkey but in grades 7 and 8 in NYS. The behavior of ratio, proportion and percent is included in the Turkish Mathematics program for the first time in grade 5, but it is introduced to NYS students starting from grade 4. *Identifying and finding equivalent ratios and expressing ratios* (RPP1) is covered in grade 5 in Turkey, while it is covered in grades 5 and 6 in

NYS. Turkish students encounter the behavior of *dividing a quantity in a given ratio* (RPP2), *converting between percents and fractions or decimals* (RPP3), and *solving problems involving percents and proportions* (RPP4) in grades 5 and 6. NYS students encounter RPP2 in grades 5 and 6, RPP3 in grade 6, and RPP4 in grades 5 through 8.

### *Comparison of Content Domain Biology*

Table 4 presents the distribution of behaviors of the TIMSS content domain Biology in Turkish and NYS Science frameworks for descriptions of all behaviors defined for the content domain Biology. There are both important similarities and differences between the two frameworks in Science. In NYS curricula, the Biology content is divided in two sections: Life Science (for Kindergarten to grade 4) and Biology (for grades 5 through 8). In Turkey, it is divided in two sections: Life Science (for grades 1 through 3) and Biology (for grades 4 through 8).

The first topic area in Life Science is characteristics and life processes of living things. There are four objectives in this topic area: *describe differences between living and nonliving things; identify common characteristics of living things* (CLP1); *compare and contrast physical and behavioral characteristics of major groups of living things* (e.g., insects, birds, mammals, and flowering plants); *identify or provide examples of animals and plants belonging to these groups* (CLP2); *relate major structures in animals to their functions* (e.g., stomach—digests food, teeth—break down food, bones—support the body, and lungs—take in air) (CLP 3); and *relate major structures in plants to their functions* (e.g., roots—absorb water, and leaves—make food) (CLP 4). Turkish students learn CLP1 in grades 3, 4, and 5, and CLP2, CLP3, and CLP4 in grade 5, while NYS students learn all four objectives throughout grades 1 to 4.

The second topic area in Life Science is life cycles, reproduction, and heredity (LCH). Students in Turkey and NYS are expected to know and be able to compare the life cycles of plants and animals. In the reproduction and heredity areas, knowledge is limited to a very basic understanding that organisms of the same kind reproduce and that offspring closely resemble their parents. There are two objectives in this topic area: *trace the general steps in the life cycle of plants* (germination, growth and development, reproduction, seed dispersal) and *animals* (birth, growth and development, reproduction, death); *recognize and compare life cycles of familiar plants* (e.g., trees and beans) and *animals* (LCH1); and *recognize that plants and animals reproduce with their own kind to produce offspring with features that closely resemble those of the parents; describe simple relationships between reproduction and survival of different kinds of plants and animals* (LCH 2). Turkish students learn both objectives in grade 5, while NYS students learn both objectives throughout grades 1 to 4.

The third topic area in Life Science is interaction with the environment (IE). Students are expected to be able to associate physical features and patterns of behavior of plants and animals with the environment. In addition, students should also be able to demonstrate a rudimentary knowledge of bodily responses to outside conditions. There are two objectives in this topic area: *associate physical features of plants and animals with the environments in which they live; identify or describe examples of certain physical or behavioral characteristics of plants and animals that help them survive in particular environments and explain why* (IE 1); and *describe bodily responses in animals to outside conditions* (e.g., heat, cold, and danger) and *to activities* (IE 2). Turkish students learn IE1 in grades 2 through 5, and IE2 in grade 5, while NYS students learn both objectives throughout grades 1 to 4.

Table 4. Distribution of Behaviors of TIMSS Content Domain Biology in NYS and Turkish Science frameworks

Subdomains	Behaviors	Turkey								NYS							
		1	2	3	4	5	6	7	8	1	2	3	4	5	6	7	8
Characteristics and life processes of living things	CLP1			x	x	x				x	x	x	x				
	CLP2					x				x	x	x	x				
	CLP3					x				x	x	x	x				
	CLP4					x				x	x	x	x				
Characteristics, classification and life processes of organisms	CCLP1							x	x					x	x	x	x
	CCLP2						x							x	x	x	x
	CCLP3						x	x						x	x	x	x
Cells and their functions	CF1							x						x	x	x	x
	CF2								x					x	x	x	x
Life cycles, reproduction and heredity	LCH1					x				x	x	x	x				
	LCH2					x				x	x	x	x				
	LCRH1							x						x	x	x	x
	LCRH2									x				x	x	x	x
	LCRH3									x				x	x	x	x
Interaction with the environment	IE1		x	x	x	x				x	x	x	x				
	IE2					x				x	x	x	x				
Diversity, adaptation and natural selection	DANS1							x						x	x	x	x
	DANS2								x					x	x	x	x
Ecosystems	LE1		x	x		x				x	x	x	x				
	LE2		x	x		x				x	x	x	x				
	LE3			x	x					x	x	x	x				
	BE1							x	x					x	x	x	x
	BE2								x					x	x	x	x
	BE3							x						x	x	x	x
	BE4							x	x					x	x	x	x
	BE5								x					x	x	x	x
Human health	LHH1			x		x				x	x	x	x				
	LHH2			x		x				x	x	x	x				
	BHH1							x						x	x	x	x
	BHH2								x					x	x	x	x

The fourth topic area in Life Science is ecosystems (LE). In this topic, the focus on ecosystems is essential to understanding the interdependence of living organisms and their relationship to the physical environment. Students are expected to learn basic concepts related to ecosystems, including energy flow and the interaction of biotic and abiotic factors. In addition, this topic assesses primary students' understanding of the ways in which human behavior can affect the environment; this is also expected of grade 4 students, with an additional emphasis on pollution. There are three objectives in this topic area: *explain that plants need the sun to produce their food, while animals eat plants or other animals; recognize that all plants and animals need food to provide energy for activity and raw material for growth and repair (LE1); describe relation-*

ships in a given community (e.g., forest, tide pool, and desert) based on simple food chains, using common plants and animals and predator-prey relationships (LE 2); and explain ways in which human behavior can have positive or negative effects on the environment; provide general descriptions and examples of the effects of pollution on humans, plants, animals, and their environments, and of ways of preventing or reducing pollution (LE 3). Turkish students learn LE1 and LE2 in grades 2, 3, and 5, and LE3 in grades 3 and 4, while NYS students learn all three objectives throughout grades 1 to 4.

The last topic area in Life Science is human health (LHH). Grade 4 students in Turkey and NYS are expected to have a rudimentary knowledge of human health, nutrition, and disease. In addition, students should demonstrate familiarity with common communicable diseases and be able to relate diet and personal habits to their effect on health. There are two objectives in this topic area: *recognize ways that common communicable diseases (e.g., colds and influenza) are transmitted; identify signs of health or illness and some methods of preventing and treating illness* (LHH 1); and *describe ways of staying healthy including eating a balanced diet and regular exercise; identify common food sources* (LHH 2). Both LHH1 and LLH2 are taught in grades 3 and 5 in Turkey, and in grades 1 through 4 in NYS.

TIMSS grade 8 content domain Science includes Biology, Chemistry, Physics, and Earth Sciences. There are some differences among participating countries in teaching these subjects. In many countries, for example, Science is taught as general Science or Integrated Science whereas in other countries, Science is taught as separate specialized subjects such as Biology, Physics, and Chemistry. In Turkey, these subjects are taught under a general Science and Technology course. The content domain Biology has six main topic areas.

The first topic area in Biology is characteristics, classification and life processes of organisms. It includes three objectives: *state the defining characteristics that differentiate among the major taxonomic groups and organisms within these groups; classify organisms on the basis of a variety of physical characteristics* (CCLP1); *locate major organs in the human body; identify the components of organ systems; explain the role of organs and organ systems in sustaining life (e.g., circulatory and respiratory); compare and contrast organs and organ systems in humans and other organisms* (CCLP2); and *explain how biological actions in response to external and internal changes work to maintain stable bodily conditions* (CCLP3). Turkish students learn CCLP1 in grades 7 and 8, CCLP2 in grade 6, and CCLP3 in grades 6 and 7, while NYS students learn all three objectives throughout grades 5 to 8.

The second topic area in Biology is cells and their functions. It includes two objectives: *explain that living things are made of cells that carry out life functions and undergo cell division, and that tissues, organs, and organ systems are formed from groups of cells with specialized structures and functions; identify cell structures and some functions of cell organelles (e.g., cell wall, cell membrane, nucleus, chloroplast, and vacuole); compare plant and animal cells* (CF1); and *describe the processes of photosynthesis (the need for light, carbon dioxide, water, and chlorophyll; production of food; and release of oxygen) and cellular respiration* (CF2). Turkish students learn CF1 in grade 6 and CF2 in grade 7, while NYS students learn both objectives throughout grades 5 to 8.

The third topic area in Biology is life cycles, reproduction, and heredity. It includes three objectives for the TIMSS assessment: *compare and contrast how different organisms (e.g., humans, plants, birds, and insects) grow and develop* (LCRH1); *compare and contrast asexual and sexual reproduction in general terms* (LCRH2); and *relate the inheritance of traits to organisms passing on genetic material to their offspring; distinguish inherited characteristics from acquired or learned characteristics* (LCRH3). Turkish students learn LCRH1 in grade 6, LCRH2 in grade 8, and LCRH3 in grade 8, while NYS students learn all three objectives throughout grades 5 to 8.

The fourth topic area in Biology is diversity, adaptation, and natural selection. It includes two objectives for the TIMSS assessment: *relate the survival or extinction of species to variation in physical/behavioral characteristics in a population and reproductive success in a changing environment* (DANS1); and *recognize that fossils provide evidence for the relative length of time major groups of organisms have existed on Earth (e.g., humans, reptiles, fish, and plants); describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time* (DANS2). Turkish students learn DANS1 in grade 7, DANS in grade 8, while NYS students learn both objectives throughout grades 5 to 8.

The fifth topic area in Biology is ecosystems. It includes five objectives: *describe the flow of energy in an ecosystem; identify different organisms as producers, consumers, and decomposers; draw or interpret food pyramids or food web diagrams* (BE1); *describe the role of living things in the cycling of elements and compounds (e.g., oxygen, carbon, and water) through Earth's surface and the environment* (BE2); *explain the interdependence of populations of organisms in an ecosystem in terms of the effects of competition and predation* (BE3); *identify factors that can limit population size (e.g., disease, predators, food resources, and drought); predict effects of changes in an ecosystem (e.g., climate, water supply, population changes, and migration) on the available resources and the balance among populations* (BE4); and *recognize that the world's human population is growing and identify reasons why (e.g., advances in medicine, and sanitation); discuss the effects of population growth on the environment* (BE5). Turkish students learn BE1 in grades 7 and 8, BE2 in grade 8, BE3 in grade 7, BE4 in grades 7 and 8, and BE5 in grade 8, while NYS students learn all five objectives throughout grades 5 to 8.

The sixth topic area in Biology is human health. It includes two objectives: *describe causes of common diseases (e.g., influenza, measles, strep throat, malaria, and HIV), methods of infection or transmission, prevention, and the importance of the body's resistance (immunity) and healing capabilities* (BHH1); and *explain the importance of diet, exercise, and lifestyle in maintaining health and preventing illness (e.g., heart disease, high blood pressure, diabetes, skin cancer, and lung cancer); identify the dietary sources and role of nutrients in a healthy diet* (BHH2). Turkish students learn BHH1 in grade 7, and BHH2 in grade 8, while NYS students learn both objectives throughout grades 5 to 8.

## Conclusions and Discussions

This study aimed to compare Mathematics and Science programs focusing on the TIMSS content domains of Numbers and Biology that produced the largest achievement gap among students from Turkey and the U.S. (New York State specifically). The study procedures included matching the objectives for the content domains Numbers and Biology as defined in the TIMSS 2007 framework with the teaching program and guidebook for the Mathematics course (grades 6 through 8) in Turkey and with NYS learning standards and core curriculum for Science and Mathematics for the U.S.

The results revealed that the Mathematics program in Turkey mostly covered TIMSS Number topics at the fifth and sixth grade levels (starting from grade 3 and ending in grade 8). Similarly, the NYS Mathematics framework also emphasized the same topics at grades 5 and 6. However, the NYS program included a closer distribution of the topics across the grade levels than the Turkish Mathematics program. For Science, the distribution of the Biology content domain was found to be closer in the NYS framework than it was in the Turkish framework. The NYS framework placed Biology sub-domains in either grades 1 through 4 or 5 through 8. In the case of Turkey, however, the distribution of the Biology sub-domains was mostly leaned toward grades 5 and 8. Moreover, the Turkish Science curriculum included only two Biology topics

placed in more than two grades: Ecosystems (grades 2, 3, and 5) and Interaction with the environment (grades 2 through 5); by contrast, NYS learning standards included each Biology sub-domain in exactly four grade levels. Moreover, Turkish students encountered the Number domain at the same level with or earlier than U.S. students, and were introduced to Biology topics later than American students. These results align with the literature that states facing a topic more frequently will help students become more familiar with the content. Familiarity and previous experience with the content may have a substantial effect on student performance on these items (Ben-Simon & Cohen, 2004).

The current study also showed that for each sub-domain related to Numbers, NYS students were required to have problem-solving activities in grades 7 or 8, while Turkish students had problem-solving activities only once (for the topic integers) in grade 7 and only once (for whole numbers) in grade 8. Although the primary school Mathematics program (MONE, 2009b) in Turkey places problem-solving among the main skills to be acquired by the students and emphasizes problem-solving by defining it as “inseparable part of Mathematics course” (p. 12), its exclusion of problem-solving activities for most Numbers sub-domains is surprising. This difference may help U.S. grade 8 students keep their content knowledge fresh by practicing with problem-solving.

For both Science and Mathematics, the TIMSS sub-domains of Numbers and Biology were over-emphasized in the NYS learning framework than in the Turkish Mathematics and Science framework. According to Linn (2003), test specification has an important role in the interpretation of international comparisons based on test scores. Too much emphasis on certain curricular topics may give certain countries an advantage, while putting others as a disadvantage. Moreover, Incikabı (2012) compared the contents of level determination examination (SBS), a national test in Turkey for entrance to high school, and TIMSS. The study revealed that the content domain Number (together with Data and Chance) as described in the TIMSS Mathematics framework was underrepresented in SBS tests. Differences in the distribution of the content in the assessment may contribute to cause poor performance because students tend to disregard topics that are not emphasized by the examinations (Kim, 2005).

Although this study investigated the cross-national curriculum consistency that may affect students' achievements, other factors may also contribute to students' performance on an international assessment, namely, socio-economic level, parents' educational level, and quality of teachers and schools. Further studies focusing on above factors would be beneficiary to reinforce the result of the current study. Another problem that may contribute to the achievement gap between students is test language (Olkun & Aydogdu, 2003). TIMSS is prepared in English, but is translated into the mother language of the countries where English is not the first language. Some mistakes during the interpretation process may fail to carry the intended goal of the test items, therefore resulting in the underachievement of non-English speakers (Dempster & Reddy, 2007). Hence, the achievement gap between Turkish and U.S. students may also be connected to the fact that U.S. students are native English speakers and that Turkish students, who are not native English speakers, receive a translated test. The language issue for TIMSS might be overcome by using a language that is general enough to allow countries to interpret the framework in ways that are most appropriate to their own needs (DeBoer, 2011).

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## **Türkiye ve Amerika Birleşik Devletlerinin İlköğretim Programlarında Bulunan Sayılar ve Biyoloji Öğrenme Alanlarının Karşılaştırmalı Analizi**

Bu çalışma TIMSS' de Türkiye' den ve Amerika'dan katılan öğrenciler arasında başarı farkının en fazla olduğu Sayılar ve Biyoloji öğrenme alanlarının içeriklerinin Türkiye ve Amerika programlarında karşılaştırmalı analizini amaçlamaktadır. Türk ve Amerika (New York State) ilköğretim programlarının incelenmesinde içerik analizi yöntemi kullanılmıştır. Karşılaştırmalı analizde TIMSS 2007'de bulunan sayılar ve biyoloji öğrenme alanları için Türkiye'de uygulanan Matematik Dersi Öğretim Programı ve Fen ve Teknoloji Dersi Öğretim Programı ile Amerika için NYS Matematik ve Fen eğitimi öğrenme kazanımları belirlenmiştir. Çalışmanın sonuçları TIMSS'de bulunan sayılar ve biyoloji öğrenme alanlarına ait kazanımların varlığının, dağılımının ve vurgulanmasının Türkiye'deki ve Amerika'daki programlarda farklı olduğunu göstermektedir. Bu tür farklılıkların uluslararası sınavlar için öğrencilerin başarılarında ve ülkelerin sıralanmalarında nasıl rol oynadığı üzerinde tartışılmıştır.

**Anahtar Kelimeler:** sayılar, biyoloji, TIMSS