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Orta Öğretim Fen Ders Kitaplarının TIMSS Çerçevesine Göre Analizi*

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ÖZET

Bu çalışmanın amacı, ortaokul fen bilgisi ders kitaplarında yer alan soruları TIMSS 2011 programı çerçevesinde ele alınan öğrenme alanı, bilişsel alan ve soru tipleri bakımından analiz etmektir. Bu amaç doğrultusunda altıncı, yedinci ve sekizinci sınıf fen ders kitaplarında yer alan sorular içerik analizi yöntemi kullanılarak incelenmiştir. Bulgular, fen bilgisi ders kitaplarındaki sorularının çoğunluğunun bilme bilişsel becerisine vurgu yaptığını, bununla birlikte çok az kısmının (yaklaşık yüzde üç) üst düzey bilişsel beceri gerektirdiğini ortaya koymaktadır. Dahası, fizik öğrenme alanı ders kitaplarındaki soruların yarısından fazlasını kapsamakta iken yer bilimleri öğrenme alanı soruları küçük bir oranını (yaklaşık yüzde on) temsil etmektedir. Bunlara ek olarak, fen bilgisi sorularının büyük çoğunluğu çoktan seçmeli sorulardan oluşmakta iken çok az kısmı açık uçlu sorular olarak ifade edilmiştir.

Anahtar Kelimeler:
Fen Ders Kitapları; Fen Eğitimi; TIMSS 2011 Çerçevesi

Genişletilmiş Özet

Çağımızda her geçen gün bütün alanlarda kendisini iyice hissettiren rekabet ortamı, gelişmiş ve gelişmekte olan ülkelerin en önemli hedefini, sürdürülebilir gelişmeyi gerçekleştirmeye zorlamaktadır. Dünya üzerinde gerçekleşen bu gelişmelerin aynı zamanda eğitim sistemini de derinden etkilediği söylenebilir. Özellikle teknolojik yarışta geri kalmak istemeyen bu ülkeler çareyi fen bilimleri ve matematik gibi alanlara önem vermekte ve bu önem doğrultusunda öğretimi geliştirmekte bulmuşlardır (Çepni, Ayas, Johnson, & Turgut, 1997). Eğitimde, özellikle öğretimde, yapılan bu çalışmaların sonuçlarını değerlendirmek için gerek ulusal gerekse uluslararası sınavlar uygulanmakta ve bunların sonuçları üzerinde hassasiyetle durulmaktadır.

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Bu çalışma, ortaokul fen bilgisi ders kitaplarında yer alan ünite sonu değerlendirme sorularını TIMSS 2011 programı çerçevesinde ele alınan öğrenme alanı, bilişsel alan ve soru tipleri bakımından analiz etmeyi amaçlamaktadır.

Bu çalışmada, ortaokul fen bilgisi ders kitaplarında yer alan ünite sonu değerlendirme sorularının 2011 TIMSS programı kriterlerine göre incelerken içerik analizi yöntemi kullanılmıştır. Bu çalışmada, veriler 2013-2014 eğitim-öğretim yılında okutulan Talim ve Terbiye Kurulu Başkanlığı tarafından onaylanmış 6. 7. ve 8. sınıflara ait fen ve teknoloji ders kitaplarındaki ünite sonu değerlendirme sorularından elde edilmiştir. Çalışmada toplam 799 soru iki uzman tarafından analiz edilmiştir. Analiz sürecinde TIMSS 2011 Fen çerçevesinde ele alınan öğrenme alanları, bilişsel alanlar ve soru tipleri temel alınmıştır.

Araştırma sonuçlarına göre, TIMSS bilişsel süreç çerçevesinde verilen bilme (% 35), uygulama (% 35) ve muhakeme (% 30) oranlarında uygulama süreci dışında büyük bir farklılığın olduğu görülmektedir (Tablo 2). Tüm sınıf düzeylerinde incelenen 799 sorunun % 67,2'si bilme bilişsel düzeyinde, % 29,9'u uygulama bilişsel düzeyinde ve % 2,9'u muhakeme bilişsel düzeyinde olduğu görülmektedir. Fen sorularının geneline bakıldığında bilme ve uygulama düzeylerindeki sorulara büyük oranlarda (% 97,1) yer verildiği görülmektedir. Ayrıca üst düzey bilişsel alanlardan olan muhakeme sürecine yönelik sorulara yeteri derecede yer verilmediği tespit edilmiştir (% 2,9).

Bunlara ek olarak, 6.sınıf (% 35), 7.sınıf (% 32,7) ve 8. sınıf (% 32,3) fen bilgisi ünite sonu soru sayıları toplamlarının birbirlerine oldukça yakın olduğu görülmektedir (Tablo 3). TIMSS 2011 fen çerçevesinde fizik alanına % 25, kimya alanına % 20, biyoloji alanına % 35 ve yer bilimleri alanına % 20 yer verildiği bilinmektedir. Fen ve teknoloji kitapları, öğrenme alanları bazında incelendiğinde, % 51,9 oranında fizik, % 16,3 oranında kimya, % 21,9 oranında biyoloji ve % 9,9 oranında yer bilimlerine ait sorulara yer verildiği tespit edilmiştir. Fizik sorularının tüm sınıflarda en yüksek oranda (% 51,9) olduğu, yer bilimlerine ise en düşük oranda (% 9,9) yer verildiği görülmektedir.

Tablo 4'te bilişsel süreçlerin, öğrenme alt alanlarına göre dağılımı incelendiğinde fizik, kimya, biyoloji ve yer bilimleri öğrenme alanlarındaki soruların çoğunlukla bilme boyutunda yoğunlaştığı hatta kimya sorularının % 81,6'sının bilme boyutundan hazırlandığı görülmektedir. Diğer bulgularla benzer şekilde üst düzey bilişsel alanlardan olan muhakeme düzeyinde sorulara en az yer verildiği, yer bilimlerindeki soruların sadece % 1,2'sinin muhakeme düzeyinde sorulardan oluştuğu tespit edilmiştir.

Tablo 5'e bakıldığında, bilme bilişsel alanında en fazla sorunun boşluk doldurma soru tipinden (170) olduğu, uygulama (134) ve muhakeme (18) alanlarında ise en fazla soruların çoktan seçmeli soru tipinden hazırlandığı görülmektedir. Muhakeme boyutunda boşluk doldurma ve Doğru/Yanlış sorularına hiç rastlanılmamıştır. İncelenen kitaplar içerisinde en fazla sorunun çoktan seçmeli sorulardan oluştuğu (260), en az sorunun ise açık uçlu sorulardan oluştuğu tespit edilmiştir.

Fen sorularının öğrenme alanlarına göre dağılımları Tablo 6'da incelendiğinde, fizik öğrenme alanında (415) en fazla soruya yer verildiği, yer bilimleri öğrenme alanında (79) ise en az soruya yer verildiği görülmektedir. Yine tablo 6 incelendiğinde fizik ve biyoloji öğrenme alanında en fazla soruların çoktan seçmeli sorulardan oluştuğu, kimya ve yer bilimleri öğrenme alanında ise en fazla soruların Doğru/Yanlış tip sorulardan oluştuğu tespit edilmiştir. Bununla beraber bütün öğrenme alanlarında en az soru açık uçlu sorulardan hazırlanmıştır.

Araştırmanın sonuçları, fen ve teknoloji ders kitaplarında ve TIMSS program çerçevesinde belirlenen öğrenme alanlarında bilme bilişsel alanını ön plana çıkardığını göstermektedir. Ayrıca, fen sorularının büyük bir çoğunluğunun bilme ve uygulama düzeylerinde olduğu, üst düzey bilişsel alanlardan olan muhakeme sürecine yönelik sorulara yeteri derecede yer verilmediği tespit edilmiştir. Araştırmanın diğer bir sonucu, fen sorularının sınıflara göre önemli bir değişkenlik göstermemesine rağmen Fizik öğrenme alanına daha çok vurgu yaptığını göstermektedir. Ders kitapları sınıflarda müfredatın yerini almaktadır ve öğretmenler çoğunlukla ders kitaplarındaki anlatım biçimini takip etmektedir. Konu vurgulanmasındaki bu farklılıkların hem öğrencilerin hem de öğretmenlerin kitaplarda içerilmeyen veya daha az önemsenen konuları ihmal etme eğilimine sevk etmektedir (Kim, 2005). Bu bağlamda ders kitaplarının içerikleri hazırlanırken gerek milli eğitimin genel amaçları, öğretim programlarında belirlenen hedefler ve kazanımlar, hem de öğrencilere uygulanmakta olan ulusal ve uluslararası sınavların içerikleri de göz önünde bulundurulmalıdır.

Araştırmanın diğer sonuçları, soru türlerinin öğrenme alanlarına ve bilişsel süreçlere göre dağılımında den en çok çoktan seçmeli ve doğru yanlış tip sorulara yer verildiğini göstermektedir. Ayrıca, açık uçlu soruların incelenen soru türleri arasında en az kapsama sahip olduğu tespit edilmiştir. Araştırmalar, öğrencilerin başarılarına kendilerinden, öğretim sürecinden, sosyal hayattan kaynaklanacak faktörler etki edebileceği gibi uygulanan soruların yapılarında ve içeriklerinde olan farklılıklar da etki edebilmektedir (Linn, 2003).

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An Analysis of Middle School Science Textbooks in terms of TIMSS Program Framework*

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ABSTRACT

The aim of this study was to analyze the questions included in the Turkish middle school science textbooks in terms of content domains, cognitive domains, and item types as stated in the TIMSS 2011 science framework. Towards this aim, current study utilized content analysis method in which the science questions in the sixth, seventh, and eighth grade textbooks were examined. The results of the study indicated that most of the textbook science questions assessed students' cognitive ability of "knowing" while only a few of them (about 3 percent) required students to use high level cognitive skills (reasoning in our case). Moreover, physics content domain represented more than half of the textbook science items while earth sciences covered only a small percentage (about 10%) in the middle school textbooks. In addition, most of the science questions were offered in the form of multiple-choice while a small proportion of them were open-ended questions.

Key Words:
Science textbooks; Science education; TIMSS 2011 framework

Introduction

Nowadays, the competition environment, which has been improving steadily, has been enforcing the developing and developed countries into sustainable development. It may be stated that these innovations affect the education profoundly. Countries particularly which do not want to fall behind those developments give importance to the subjects such as natural science and mathematics (Çepni, Ayas, Johnson, & Turgut, 1997). In order to determine the results of these studies, exams

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are performed on both national and international scales and the results of them are investigated in detail.

International assessment and evaluation tests have been performed by analyzing the correlations between various applications and success so as to determine the best practices and to inform the other test performers in other countries (Bağcı-Kılıç, 2002). To observe their developments in mathematics and natural sciences, countries attend such exams as TIMSS (Trends in International Mathematics and Science Study), PISA (Programme for International Student Assessment) and PIRLS (Progress in International Reading Literacy Study). To view the results of such tests as TIMSS, which has universal validity, is essential for countries such as Turkey which have structural problems and want to take concrete steps (Oral & McGivney, 2013).

When TIMSS 2011 results were examined, Turkey showed a relative increase. However, it stayed below the 4th Grade and 8th Grade level determined by TIMMS criteria (Martin, Mullis, Foy, & Stanco, 2012; Mullis, Martin, Foy, & Arora, 2012). So as to determine the reasons of this performance, the tests for attending secondary schools in Turkey has been compared with the tests performed on an international scale.

İncikabi, Kurnaz and Pektaş (2013) examined the contents of SBS (Level Determination Examination) mathematics and science in view of the cognitive and structural properties of TIMSS. The findings reveal that whereas SBS science questions focus on conceptual questions, SBS mathematics questions focus on algorithmic questions. Furthermore, in both areas there is a lack of graphical and logical questions. İncikabi (2012) examined the contents of the mathematical questions of SBS and TIMSS exams in terms of learning and cognitive areas. The findings indicate that these two exams do not have significant differences in accordance with the learning area. SBS exams do not use open ended questions as they are in TIMSS exam. There are more practical questions than reasoning questions. According to the report published by Oral and McGivney (2013), inequality plays an important role in Turkish education system. Textbooks and course materials together with other factors take an important part in the success of children.

Textbooks are of great importance for teaching the content and they are indispensable for teaching science and technology (Tornroos, 2005; Yager, 1996).

Textbooks are the basic sources for the teaching of science and technology. They are also the most vital supporters of the teachers and take places of the curriculum in most cases (Stake & Easley, 1978). Tornroos (2005) identified the textbooks as the potential curriculum. In some studies, science and technology textbooks in Turkey do not support the aims of science education and thus they do not help students have long lasting learning effect (Köseoğlu, 2004; Uzun, Gelbal & Öğretmen, 2010). Özden (2007) indicated that the textbooks and teaching programme should be revised again according to his research in terms of the attitudes of science and technology in Turkey. Bozdoğan and Yalçın (2005) suggest that both the visual aspect and the content are supposed to be developed in order to increase the attitude of children towards science. When the literature has been reviewed, it can be seen that mathematics textbooks have been examined in accordance with the TIMSS programme framework (Mayer, Sims, & Tajika, 1995; Vincent and Stacey, 2008), however, science textbooks have not yet been examined in accordance with the TIMSS programme framework.

Based on the above literature review, this study aims to analyze the consolidation questions, which are at the end of the units of middle school science textbooks, in terms of cognitive domains, science content domains and question types according to the TIMSS 2011 programme framework. The concerning questions are;

1. How were various cognitive domains distributed in the questions placed in the middle school science textbooks?

2. How were various content domains distributed in the questions placed in the middle school science textbooks?

3. How were various item types distributed in the questions placed in the middle school science textbooks?

Methodology of the Research

In this study, the unit consolidation questions on the secondary school science textbooks have been examined in terms of TIMSS 2011 programme criteria. Content analysis is used to systemize and digitize the pre-organized data (Fraenkel, & Wallen, 2000).

In the study, the consolidation questions at the end of each unit have been gathered from the 6th, 7th and 8th grade science and technology textbooks that are confirmed by the Head Council of Education and Morality and studied during 2013-2014 academic year. A total of 799 questions have been examined by two experts in the study. In the analysis process, content domains, cognitive domains and item types have been determined according to TIMSS 2011 science framework (Chart 1). The detailed explanations for content and cognitive domains were provided in Appendix A, as they were stated in the TIMSS 2011 framework. The consistency rate has been calculated as 0.85 according to Miles and Huberman (1994) formula. Consensus has been agreed on the disputed issues. The frequency and percentage of content domains, cognitive domains and structures of the questions in the science textbooks, broken down by grade levels, were determined. The interpretation of the analyses is descriptive in nature.

Table 1.
Evaluation criteria

Content domains	Biology – Chemistry - Physics – Earth sciences
Cognitive domains	Knowing – applying – reasoning
Item types	Open ended – Gap filling – true / false – multiple choice - matching

Research Findings

When Table 2 is examined, the total number of questions included in the content domains is relatively close across the grade levels with 35% at sixth grade, 32.7% at seventh grade, and 32.3% at eighth grade. Except for the cognitive domain of applying, consisting of 42% of the TIMSS 2011 assessment questions, there is a wide difference in the cognitive domains of knowing and reasoning that cover 34% and 24% of TIMSS 2011 science assessments respectively. Overall, among the 799 questions included in the sixth, seventh and eighth grade textbooks, 67.2 % is on the knowing domain, 29.9 % is on the applying domain, and 2.9 % is on the reasoning domain. When generally evaluated, the questions requiring knowing and applying cognitive processes covered a high portion of the all questions with the percentage of 97.1 %. Furthermore, textbooks' inclusion of the questions regarding upper level cognitive areas such as reasoning with 2.9 % is not enough.

Table 2.
The distribution of the questions according to cognitive domains taking place in science textbooks

Grades	Knowing	Applying	Reasoning	Total
Sixth	178 (63.5)	89 (31.8)	13 (4.6)	280 (35.0)
Seventh	202 (77.3)	56 (21.4)	3 (1.1)	261 (32.7)
Eighth	157 (60.9)	94 (36.4)	7 (2.7)	258 (32.3)
Total	537 (67.2)	239 (29.9)	23 (2.9)	799 (100)

Note: *The percentage is shown in brackets.*

When Table 3 is examined, Turkish science textbooks place a high emphasis on physics with 51.9% and deemphasize the content domains of chemistry (16.3%), biology (21.9%) and earth sciences (the least emphasized content domain with 9.9%) compared to the 2011 TIMSS science assessments which place physics with 25%, chemistry with 20%, biology with 36 %, and earth sciences with 19%. Across the grade levels, physics content domain takes highest proportion of the textbook questions at each grade. Moreover, percentage distribution of the physics and biology does not differ too much from one grade to the other grades. While chemistry almost doubles its percentage distribution in the seventh grade textbooks, earth sciences do not have any question at the same grade level.

Table 3.
The distribution of the questions according to content domains taking place in science textbooks

Grades	Physics	Chemistry	Biology	Earth Sciences
Sixth	136 (48.6)	30(10.7)	68(24.3)	46(16.4)
Seventh	140 (53.6)	65 (24.9)	56 (21.5)	0
Eighth	139 (53.9)	35 (13.6)	51(19.8)	33(12.8)
Total	415 (51.9)	130 (16.3)	175(21.9)	79 (9.9)

Note: *The percentage is shown in brackets.*

Table 4 shows distribution of the science textbook questions in terms of cognitive processes and content domains. All content domains, particularly chemistry with 81.6%, focus on knowing cognitive domain. Applying is the second most covered cognitive domain in all content domains. Similar to the above research findings, reasoning cognitive domain takes the least attention in all content domains, especially in earth sciences having 1.2 percent of reasoning questions.

Table 4.
Distribution of the science textbook questions in terms of cognitive processes and content domains

	Knowing	Applying	Reasoning
Physics	254 (61.2)	145 (34.9)	16 (3.9)
Chemistry	106 (81.6)	22 (16.9)	2 (1.5)
Biology	135 (77)	36 (20.8)	4 (2.2)
Earth Sciences	42 (53.2)	36 (45.6)	1 (1.2)

Note: *The percentage is shown in brackets.*

Table 5 shows the distribution of the question types among the cognitive domains. In general, most of the questions in the middle school science textbooks are in the type of multiple choice (%32.5), true/false (%25.3) and gap filling (19.1) while the open ended questions are the least preferred question types in the textbooks with 8%. On the other hand, two question formats are used in the TIMSS 2011 assessment—multiple-choice and constructed-response. Moreover, 53 percentage of points represented by all the questions will come from constructed-response questions (Mullis et al., 2012). Hence, Turkish students' scores might be lowered, since they have been instructed with a textbook that de-emphasis items requiring constructed-response.

According to Table 5, most of the questions on the knowing domain are true/false types (170), while most of the questions on applying (134) and reasoning (18) domains are in the type of multiple choice. No true/false questions or gap filling questions concerning reasoning domain have been confronted. Among the examined science textbooks, it has been detected that most of the questions consist of multiple choice questions (260), while the least of the questions consist of open ended questions.

Table 5.
Distribution of the question types among the cognitive domains

	Open ended	Gap filling	True/False	Multiple choice	Matching
Knowing	28(3.5)	137(17.1)	170(21.3)	108(13.5)	94(11.8)
Applying	32(4)	16(2)	32(4.0)	134(16.8)	25(3.1)
Reasoning	4(0.5)	0(0)	0(0)	18(2.3)	1(0.1)
Total	64(8)	153(19.1)	202(25.3)	260(32.5)	120(15)

Note: *The percentage is shown in brackets.*

When Table 6 is examined, most of the science textbook questions are multiple choice questions in physics and biology with 17.9% and 7.4% respectively, while most of the questions are true / false questions in chemistry and earth sciences (5.1% and 2.4%). In addition, in all content domains, open ended questions take up the least part.

Table 6.
Distribution of the question types among the content domains

	Open ended	Gap filling	True/False	Multiple choice	Matching
Physics	35(4.4)	83(10.4)	100(12.5)	143(17.9)	54(6.8)
Chemistry	2(0.3)	19(2.4)	41(5.1)	40(5)	28(3.5)
Biology	14(1.8)	36(4.5)	42(5.3)	59(7.4)	24(3)
Earth Sciences	13(1.6)	15(1.9)	19(2.4)	18(2.3)	14(1.8)

Note: *The percentage is shown in brackets.*

Discussion and Conclusion

This study focuses on the unit consolidation questions on the secondary school science textbooks which have been examined according to 2011 TIMSS programme criteria in terms of learning areas, cognitive process ability and question types. The findings of the research are limited with the text books examined.

The results reveal that knowing cognitive domain takes the largest part in the science textbooks among all cognitive domains determined by TIMSS programme. What is more, knowing and applying domains form most of the science questions, while reasoning domain that require high level of cognitive skills forms less part in science questions placed in the textbooks. Thus, it is obvious that upper level cognitive processes do not take part in the textbooks. However, this situation contradicts the general aims of secondary education which provide great emphasis on high level thinking skills (such as associating and reasoning), and which set the criteria for national mathematics and science education programmes (MEB, 2013a, 2013b). The science education reforms all over the world have been derived from the constructive approach. These reforms aim to convert the traditional teaching techniques into strategies based on discovering and investigating phenomenon in real life (National Research Council, 1996). Furthermore, the constructive approach suggests students to involve in the learning experiences in which they can develop their learning and thinking abilities (Cobb, 1994; Driver, Asoko, Leach, Mortimer, & Scott, 1994). It also complies with the taxonomy set by Bloom, Englehart, Furst, Hill, and Krathwohl (1956) based on high level thinking skills. Within this regard, while analysis syntheses and evaluation steps form the upper thinking abilities, knowledge step forms the lower level thinking abilities. Indeed, education experiences based on analysis, syntheses and evaluation develop the upper level thinking abilities including problem solving, creative thinking and generalization (Wilks, 1995). Science teachers who are aware of the lack of their students' reasoning frequently utilize activities to develop upper level abilities. However, they rarely consider these abilities as educational targets that should be followed (Zohar & Dori, 2003). Thus, not including the activities requiring upper level cognitive thinking in the textbooks may lead teachers to neglect these activities. As a result, it prevents to develop the upper level thinking abilities which are planned. Besides, Pektaş (2012), İncikabi, (2012) and İncikabi and friends (2013) suggest that exams for secondary education in Turkey (SBS) lack in the higher cognitive skills such as reasoning. It is essential that textbooks and standard exams should be reorganized so as to develop the cognitive abilities of the students with various levels (Kim, 2005).

Another result of the study indicates that science questions vary across content domains, while they tend to focus on Physics content domain. Textbooks replace the curriculum in classes and teachers mainly follow them. Both teachers and the students tend to neglect certain or less important subjects which are not included in the textbooks (Kim, 2005). Thus, while preparing the textbooks, both the aims of national education, and the objectives of the exams on national and international scale should be taken into consideration.

The current study also shows that multiple choice questions and true-false questions take the biggest part in the science textbooks. Furthermore, it has been determined that open ended questions take the least part in the examined questions. Just as teaching processes and other factors related to social life can affect the success of the students, the variations in the contents and structures of the questions can affect their academic performance (Linn, 2003). The results obtained in the current study is valuable for policy/decision makers in education while developing teaching programs and designing textbooks that are in line with the stated aims set by the related curriculum. Moreover, future qualitative and quantitative research that involves utilizing high level of cognitive skills in the classroom environment would be beneficiary to support the results obtained in the current study.

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Appendix

Appendix A: Explanations of TIMSS Content and Cognitive Domains

Science Content Domains –Eighth Grade

Content Domain	Content Categories	Explanations
Biology	Characteristics, Classification, and Life Processes of Organisms	1) 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. 2) Locate major organs in the human body; identify the components of organ systems; explain the role of organs and organ systems in sustaining life; compare and contrast organs and organ systems in humans and other organisms. 3) Explain how biological actions in response to external and internal changes work to maintain stable bodily conditions
	Cells and Their Functions	1) 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 compare plant and animal cells. 2) Describe the processes of photosynthesis and cellular respiration.
	Life Cycles, Reproduction, and Heredity	1) Compare and contrast how different organisms grow and develop. 2) Compare and contrast asexual and sexual reproduction in general terms. 3) Relate the inheritance of traits to organisms passing on genetic material to their offspring; distinguish inherited characteristics from acquired or learned characteristics.
	Diversity, Adaptation, and Natural Selection	1) Relate the survival or extinction of species to variation in physical/behavioral characteristics in a population and reproductive success in a changing environment. 2) Recognize that fossils provide evidence for the relative length of time major groups of organisms have existed on Earth; describe how similarities and differences among living species and fossils provide evidence of the changes that occur in living things over time.
	Ecosystems	1) 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. 2) Describe the role of living things in the cycling of elements and compounds through Earth's surface and the environment. 3) Explain the interdependence of populations of organisms in an ecosystem in terms of the effects of competition and predation. 4) Identify factors that can limit population size; predict effects of changes in an ecosystem on the available resources and the balance among populations. 5) Recognize that the world's human population is growing and identify reasons why; discuss the effects of population growth on the environment.
	Human Health	1) Describe causes of common diseases, methods of infection or transmission, prevention, and the importance of the body's resistance (immunity) and healing capabilities. 2. Explain the importance of diet, exercise, and lifestyle in maintaining health and preventing illness; identify the dietary sources and role of nutrients in a healthy diet.
Chemistry	Classification and composition of matter	1. Classify or compare substances on the basis of characteristic physical properties that can be demonstrated or measured (e.g., density, thermal or electrical conductivity, solubility, melting or boiling point, magnetic properties).

		2. Recognize that substances may be grouped according to similar chemical and physical properties; describe properties of metals that distinguish them from nonmetals. 3. Differentiate between pure substances (elements and compounds) and mixtures (homogeneous and heterogeneous) on the basis of their formation and composition, and provide or identify examples of each (may be solid, liquid, or gas). 4. Describe the structure of matter in terms of particles, including molecules as combinations of atoms (e.g., H_2O, O_2, CO_2) and atoms as composed of subatomic particles (electrons surrounding a nucleus containing protons and neutrons).
	Properties of matter	1. Select or describe physical methods for separating mixtures into their components (e.g., filtration, distillation, -dissolution); define solutions in terms of substance(s) (solid, liquid, or gas solutes) dissolved in a solvent; relate concentration to the amounts of solute or solvent; explain the effect of factors such as temperature, stirring, and particle size on the rate at which materials dissolve. 2. Relate the behavior and uses of water to its physical properties (e.g., melting point and boiling point, ability to dissolve many substances, thermal properties, expansion upon freezing). 3. Compare the properties of common acids and bases (acids have a sour taste and react with metals; bases usually have a bitter taste and slippery feel; strong acids and bases are corrosive; both acids and bases dissolve in water and react with indicators to produce different color changes; acids and bases neutralize each other).
	Chemical change	1. Differentiate chemical from physical changes in terms of the transformation (reaction) of one or more pure substances (reactants) into different pure substances (products); provide evidence that a chemical change has taken place based on common examples (e.g., temperature change, gas production, color change, light emission). 2. Recognize that mass is conserved during chemical change; recognize that some chemical reactions release energy (e.g., heat, light) while others absorb it; classify familiar chemical changes as either releasing or absorbing heat (e.g., burning, neutralization, cooking). 3. Recognize that oxygen is needed in common oxidation reactions (combustion, rusting, tarnishing); relate its importance to fire safety and preservation of metal objects (coins, cars, cookware, statues); order familiar substances by how readily they burn, rust, or tarnish.
Physics	Physical States and Changes in Matter	1. Apply knowledge about the movement of and distance between particles to explain the physical properties of solids, liquids, and gases (volume, shape, density, compressibility). 2. Describe melting, freezing, boiling, evaporation, and condensation as changes of state resulting from heating and cooling; relate the rate or extent of these processes to physical factors (e.g., surface area, dissolved substances, temperature); recognize that temperature remains constant during changes of state; explain that mass remains constant during physical changes (e.g., change of state, dissolving solids, thermal expansion).
	Energy Transformations, Heat, and Temperature	1. Identify different forms of energy (e.g., mechanical, light, sound, electrical, thermal, chemical); describe simple energy transformations (e.g., combustion in an engine to move a car, electrical energy to power a lamp, light energy to chemical energy in photosynthesis, hydroelectric power, changes between potential and kinetic energy); and apply knowledge of the concept of conservation of total energy. 2. Relate heating to the transfer of energy from an object at a higher temperature to one at a lower temperature; compare the relative thermal conductivity of different materials; compare and contrast methods of heat transfer (conduction, convection, and radiation). 3. Relate temperature changes to changes in volume and/or pressure and to changes in the speed of particles.

	Light and Sound	1. Describe or identify basic properties of light (e.g., transmission through different media; speed of light; reflection, refraction, absorption; splitting of white light into its component colors); relate the appearance or color of objects to the properties of reflected or absorbed light; solve practical problems involving the reflection of light from plane mirrors and the formation of shadows; interpret simple ray diagrams to identify the path of light and locate reflected or projected images using lenses. 2. Recognize the characteristics of sound (loudness, pitch, amplitude, frequency); describe or identify some basic properties of sound (need for a medium for transmission, reflection and absorption by surfaces, and relative speed through different media).
	Electricity and Magnetism	1. Describe the flow of current in an electrical circuit; draw or identify diagrams representing complete circuits (series and parallel); classify materials as electrical conductors or insulators; describe factors that affect currents in circuits; recognize that there is a relationship between current and voltage in a circuit. 2. Describe the properties of permanent magnets and electromagnets and the effects of magnetic force; describe uses of permanent magnets and electromagnets in everyday life (e.g., doorbell, recycling factories).
	Forces and Motion	1. Describe the motion (uniform and non-uniform) of an object in terms of its position, direction, and speed; describe general types of forces (e.g., weight as a force due to gravity, contact force, buoyant force, friction); predict changes in motion (if any) of an object based on the forces acting on it. 2. Explain observable physical phenomena in terms of density differences (e.g., floating or sinking objects, rising balloons). 3. Demonstrate basic knowledge of work and the function of simple machines (e.g., levers and ramps) using common examples. 4. Explain pressure in terms of force and area; describe effects related to pressure (e.g., atmospheric pressure as a function of altitude, ocean pressure as a function of depth, evidence of gas pressure in balloons, fluid levels).
Earth Science	Earth's Structure and Physical Features	1. Describe the structure and physical characteristics of Earth's crust, mantle, and core as provided by observable phenomena (e.g., earthquakes, volcanoes); describe the characteristics and uses of rocks, minerals, and soils; describe the formation of soils. 2. Compare the physical state, movement, composition and relative distribution of water on Earth. 3. Recognize that Earth's atmosphere is a mixture of gases, and identify the relative abundance of its main components; relate changes in atmospheric conditions to altitude.
	Earth's Processes, Cycles, and History	1. Describe the general processes involved in the rock cycle; identify or describe physical processes and major geological events that have occurred over millions of years (e.g., erosion, volcanic activity, mountain building, and plate movement); explain the formation of fossils and fossil fuels. 2. Diagram or describe the processes in Earth's water cycle, referencing the Sun as the source of energy; and the role of cloud movement and water flow in the circulation and renewal of fresh water on Earth's surface. 3. Compare seasonal climates in relation to latitude, altitude and geography; identify or describe causes of long- and short-term climatic changes (e.g., ice ages, global warming, volcanic eruptions, and changes in ocean currents); interpret weather data/ maps, and relate changing weather patterns to global and local factors in terms of such factors as temperature, pressure, precipitation, and wind speed and direction.
	Earth's Resources, Their Use and Conservation	1. Provide examples of renewable and nonrenewable resources; discuss advantages and disadvantages of different energy sources; describe methods of conservation of resources and methods of waste management (e.g., recycling); relate some environmental concerns to their possible causes and effects (e.g., pollution, global warming, deforestation, desertification); present ways in which science, technology, and human behavior can be used to address these concerns.

	2. Explain how common methods of agriculture and land use (e.g., farming, tree harvesting, and mining) can affect land resources; describe how fresh water is obtained (e.g., purification, desalination, irrigation); explain the importance of water conservation.
Earth in the Solar System and the Universe	1. Explain phenomena on Earth (day and night, year, seasons in the northern and southern hemisphere, tides, phases of the moon, eclipses, appearance of the Sun, moon, planets, and constellations) in terms of the relative movements, distances, and sizes of Earth, the moon, and other bodies in and outside the solar system. 2. Compare and contrast the physical features of Earth with the moon and other planets (e.g., atmosphere, temperature, water, distance from the Sun, period of revolution and rotation, ability to support life); recognize the role of gravity in the solar system (e.g., tides, keeping the planets and moons in orbit, pulling us to Earth's surface).

Note: *Taken from Mullis et al. (2012).*

Cognitive Domains of TIMSS 2011

Knowing	Recall/Recognize	Make or identify accurate statements about science facts, relationships, processes, and concepts; identify the characteristics or properties of specific organisms, materials, and processes.
	Define	Provide or identify definitions of scientific terms; recognize and use scientific vocabulary, symbols, abbreviations, units, and scales in relevant contexts.
	Describe	Describe organisms, physical materials, and science processes that demonstrate knowledge of properties, structure, function, and relationships.
	Illustrate with Examples	Support or clarify statements of facts or concepts with appropriate examples; identify or provide specific examples to illustrate knowledge of general concepts.
	Demonstrate Knowledge of Scientific Instruments	Demonstrate knowledge of how to use science apparatus, equipment, tools, measurement devices, and scales.
Applying	Compare/Contrast/ Classify	Identify or describe similarities and differences between groups of organisms, materials, or processes; distinguish, classify, or order individual objects, materials, organisms, and processes based on given characteristics and properties.
	Use Models	Use a diagram or model to demonstrate understanding of a science concept, structure, relationship, process, or biological or physical system or cycle (e.g., food web, electrical circuit, water cycle, solar system, atomic structure).
	Relate	Relate knowledge of an underlying biological or physical concept to an observed or inferred property, behavior, or use of objects, organisms, or materials.
	Interpret Information	Interpret relevant textual, tabular, or graphical information in light of a science concept or principle.
	Find Solutions	Identify or use a science relationship, equation, or formula to find a qualitative or quantitative solution involving the direct application/demonstration of a concept.

	Explain	Provide or identify an explanation for an observation or natural phenomenon, demonstrating understanding of the underlying science concept, principle, law, or theory.
Reasoning	Analyze	Analyze problems to determine the relevant relationships, concepts, and problem-solving steps; develop and explain problem-solving strategies.
	Integrate/Synthesize	Provide solutions to problems that require consideration of a number of different factors or related concepts; make associations or connections between concepts in different areas of science; demonstrate understanding of unified concepts and themes across the domains of science; integrate mathematical concepts or procedures in the solutions to science problems.
	Hypothesize/Predict	Combine knowledge of science concepts with information from experience or observation to formulate questions that can be answered by investigation; formulate hypotheses as testable assumptions using knowledge from observation and/or analysis of scientific information and conceptual understanding; make predictions about the effects of changes in biological or physical conditions in light of evidence and scientific understanding.
	Design	Design or plan investigations appropriate for answering scientific questions or testing hypotheses; describe or recognize the characteristics of well-designed investigations in terms of variables to be measured and controlled and cause and- effect relationships; make decisions about measurements or procedures to use in conducting investigations.
	Draw Conclusions	Detect patterns in data, describe or summarize data trends, and interpolate or extrapolate from data or given information; make valid inferences on the basis of evidence and/or understanding of science concepts; draw appropriate conclusions that address questions or hypotheses, and demonstrate understanding of cause and effect.
	Generalize	Make general conclusions that go beyond the experimental or given conditions, and apply conclusions to new situations; determine general formulas for expressing physical relationships.
	Evaluate	Weigh advantages and disadvantages to make decisions about alternative processes, materials, and sources; consider scientific and social factors to evaluate the impact of science and technology on biological and physical systems; evaluate alternative explanations and problem-solving strategies and solutions; evaluate results of investigations with respect to sufficiency of data to support conclusions.
	Justify	Use evidence and scientific understanding to justify explanations and problem solutions; construct arguments to support the reasonableness of solutions to problems, conclusions from investigations, or scientific explanations.

Note: *Taken from Mullis et al. (2012).*