A Comparison of the 2011 Grade 8 NAEP and TIMSS Mathematics and Science Frameworks

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Executive Summary

The National Assessment of Educational Progress (NAEP), a congressionally mandated assessment program, is conducted to report what students across the United States know and can do in several subject areas, including mathematics and science. The Trends in International Mathematics and Science Study (TIMSS), an international comparative assessment of student achievement in mathematics and science, is conducted in more than 50 countries, including the United States.

The NAEP and TIMSS mathematics and science assessment frameworks are organized around two dimensions—a content dimension and a cognitive dimension. The content dimension defines what knowledge and skills should be covered in the assessment. While NAEP and TIMSS use different terminology and approaches to describe their frameworks' cognitive dimensions, both assessments include a broad range of items requiring varying levels of application and cognitive demand.

To compare the similarities and differences in the content and cognitive dimensions of the NAEP and TIMSS frameworks, two expert panels were convened—one for mathematics and one for science. The six-member panels were formed based on the panel members' expertise in mathematics and science education and their familiarity with the NAEP and TIMSS assessments. To compare the content dimensions of the two frameworks in each subject, panel members used a 4-point scale—where a higher number indicated greater similarity—to rate the content at three levels of specificity: (1) objectives/content statements; (2) content areas/domains; and (3) overall framework. To compare the cognitive dimensions of the two frameworks in each subject, each panel worked as a group to prepare a set of summary statements that captured the major differences between the two frameworks.

The comparisons of the NAEP and TIMSS mathematics frameworks found that, in general, there were many similarities between the two frameworks. At the overall framework level, all six experts assigned a rating of 3 ("quite similar, but with some differences"). All of the NAEP and TIMSS mathematics content areas were judged by the expert panel to be similar, even though the organization of the mathematics content dimensions differed (i.e., measurement is an explicit content area in NAEP, but not in TIMSS). Seventy percent of the NAEP mathematics objectives were rated as similar to objectives in the TIMSS framework,

and 85 percent of the TIMSS mathematics objectives were rated as similar to objectives in the NAEP framework.

The expert panel discussions of the NAEP and TIMSS mathematics frameworks focused on other ways in which the frameworks differed. The cognitive dimensions are defined differently in the two frameworks. While there is some correlation between the levels of complexity in the NAEP framework and the cognitive domains in the TIMSS framework, especially at the low and high levels of cognitive demand, the two dimensions are not interchangeable.

The comparisons of the NAEP and TIMSS science frameworks found that some aspects of the frameworks were similar, while others were not similar. At the overall framework level, four of the six experts assigned a rating of 3 ("quite similar, but with some differences"), while the remaining two experts assigned a rating of 2 ("quite dissimilar, but with some overlap"). Only one of the three content areas in the NAEP framework (Life Science) was rated as similar to the corresponding content area in the TIMSS framework (Biology). Overall, slightly more than half (56 percent) of the NAEP science content statements were rated as similar to objectives in the TIMSS science framework, while slightly less than half (44 percent) of the TIMSS science objectives were rated as similar to content statements in the NAEP science framework.

The expert panel discussions of the NAEP and TIMSS science frameworks focused on several aspects of the two frameworks. There are notable differences in the distribution of assessment time across content areas. The inclusion of separate subscales for Chemistry and Physics in TIMSS results in a larger number of Physical Science topics in TIMSS than in NAEP. With some exceptions, it is possible to align the cognitive categories of the NAEP science practices with the TIMSS cognitive domains. The TIMSS framework has slightly more emphasis on Knowing and less on Reasoning than the NAEP framework.

It is important to keep in mind that this study is a framework-to-framework comparison of the 2011 grade 8 NAEP and TIMSS mathematics and science assessments. It focuses on the frameworks' content and cognitive dimensions and does not compare any of the assessment items. Some differences in the framework content may not be reflected in corresponding differences in the assessments.

Introduction

The National Assessment of Educational Progress (NAEP), a congressionally mandated assessment program, is conducted to report what students across the United States know and can do in several subject areas, including mathematics and science. The Trends in International Mathematics and Science Study (TIMSS), an international comparative assessment of student achievement in mathematics and science, is conducted in more than 50 countries, including the United States. In 2011, the National Center for Education Statistics (NCES) administered both NAEP and TIMSS to a sample of students in grade 8. In addition, NCES conducted a study to link the score scales of these two assessments to project TIMSS scores in mathematics and science for those states that participated only in NAEP—*U.S. States in a Global Context: Results From the 2011 NAEP-TIMSS Linking Study* (http://nces.ed.gov/nationsreportcard/pubs/studies/2013460.asp).

When different frameworks are used to develop two assessments used in a linking study, a comparison of the assessment frameworks and the resulting item pools helps to better understand the similarities and differences in the constructs being measured. Subject area frameworks describe the intended knowledge and skills to be assessed and provide information on other important assessment features, such as areas of content emphasis.

Because NAEP and TIMSS have distinct assessment frameworks, the NCES Assessment Division commissioned this framework comparison study to assess the similarity of knowledge and skills targeted by the NAEP and TIMSS 2011 grade 8 assessments in mathematics and science. A separate study that evaluated the fit of the TIMSS items to the NAEP framework was also commissioned by NCES —*A Comparison of the 2011 Trends in International Mathematics and Science Study (TIMSS) Assessment and the 2011 National Assessment of Educational Progress (NAEP) Mathematics and Science Assessments* (http://nces.ed.gov/nationsreportcard/pubs/studies/2013463.asp). Used together, these studies help to provide a comprehensive picture of the similarities and differences between the mathematics and science constructs assessed by the 2011 NAEP and TIMSS assessments. The investigation of both the frameworks and the item pools contributes to the body of evidence needed to inform the extent to which results from the different assessments can be directly compared.

2011 NAEP and TIMSS Mathematics and Science Frameworks

The 2011 NAEP and TIMSS mathematics and science assessment frameworks[1] are organized around two dimensions—a content dimension and a cognitive dimension. The content dimension defines what knowledge and skills should be covered in the assessment. While the NAEP and TIMSS frameworks use different terminology and different approaches to describe the cognitive dimensions, both frameworks require a broad range of application and cognitive demand.

Mathematics Content Dimension

The NAEP mathematics framework divides the grade 8 mathematics content to be assessed into five broad content areas: Number Properties and Operations; Measurement; Geometry; Data Analysis, Statistics, and Probability; and Algebra. Each content area is further broken down into subtopics that include a set of grade-specific content objectives. For some objectives, there are associated statements in the assessment specifications document[2] that further clarify the mathematics content to be included for a specific grade. There are 24 subtopics and 101 objectives at grade 8. For more information, see appendix table A-1 in this report and the 2011 NAEP grade 8 mathematics framework.[3]

The TIMSS mathematics framework at grade 8 defines four content domains[4]—Number; Geometry; Data and Chance; and Algebra—which are divided into topics and specific assessment objectives. There are 13 topics and 41 objectives at grade 8. For more information, see appendix table A-2 in this report and the 2011 TIMSS framework.[5]

Table 1 illustrates how each framework organizes the mathematics content and the target percentage of the assessment devoted to each content area. Geometry and Measurement are distinct content areas in the NAEP framework; they are combined in the TIMSS framework. Also note that the NAEP percentages are based on the total number of questions, but the TIMSS percentages are based on assessment time.

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[1] The mathematics and science frameworks used for the 2011 NAEP assessments were last revised in 2007 for the 2009 assessments.
[2] The NAEP mathematics assessment specifications document can be accessed at http://www.nagb.org/publications/frameworks/mathematics/2009-mathematics-specification.html.
[3] The NAEP mathematics framework can be accessed at http://www.nagb.org/content/nagb/assets/documents/publications/frameworks/math-2011-framework.pdf.
[4] The TIMSS content domains are analogous to the NAEP content areas.
[5] The TIMSS mathematics framework can be accessed at http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Table 1. NAEP and TIMSS mathematics framework targets for grade 8, by content area/domain: 2011

NAEP mathematics framework		TIMSS mathematics framework	
Content area	Target percent	Content domain	Target percent
Number Properties and Operations	20	Number	30
Geometry	20	Geometry	20
Measurement	15		
Data Analysis, Statistics, and Probability	15	Data and Chance	20
Algebra	30	Algebra	30

NOTE: The target percentages shown in the table indicate the percentage of assessment items for NAEP and the percentage of assessment time for TIMSS. Geometry and Measurement are distinct content areas in the NAEP framework, but are combined in the TIMSS framework.
SOURCE: National Assessment Governing Board, *Mathematics Framework for the 2011 National Assessment of Educational Progress,* 2010; and International Association for the Evaluation of Educational Achievement, *TIMSS 2011 Assessment Frameworks,* 2009.

Mathematics Cognitive Dimension

The NAEP framework defines the cognitive dimension using three levels of complexity. The levels of complexity in the NAEP framework have the following distribution of assessment time:

- Low complexity (25 percent);
- Moderate complexity (50 percent); and
- High complexity (25 percent).

The TIMSS mathematics framework defines the cognitive dimension in terms of three cognitive domains, with the following distribution of assessment time:

- Knowing (35 percent);
- Applying (40 percent); and
- Reasoning (25 percent).

In NAEP, the levels of complexity form an ordered description of the demands that an item places on student thinking. These hierarchical levels are used in combination with the content objectives to ensure the assessment item pool is balanced among recalling mathematical facts and procedures (low complexity), using and explaining mathematical conceptual and procedural understanding (moderate complexity), and reasoning with and about mathematics content (high complexity).

The cognitive domains used in TIMSS cover a range of cognitive skills and abilities required of students as they use their mathematical content knowledge to respond to assessment items. Students are expected to recall facts (Knowing), to use these facts to solve problems (Applying), and to make complex interpretations of multi-step problems (Reasoning). When used in a mathematical context, the cognitive domains articulate specific expectations of how students use mathematical knowledge. For example, an item within the cognitive domain of Knowing may ask students to recall facts about different types of triangles. Applying would expect students to use these facts about triangles to solve problems. Reasoning would then ask students to prove an attribute of a triangle using geometric properties as evidence that this attribute exists.

Science Content Dimension

The NAEP science framework divides the grade 8 science content to be assessed into three broad content areas: Life Science; Physical Science; and Earth and Space Sciences. Each content area is further broken down into topics and subtopics that include a set of grade-specific content statements. Each subtopic also has an associated set of content boundaries in the assessment specifications document[6] that further clarifies the science content to be included for a specific grade level. There are 18 subtopics and 43 content statements at grade 8. For more information, see appendix table A-3 and the 2011 NAEP grade 8 science framework.[7]

The TIMSS science framework at grade 8 defines four content domains[8]—Biology, Chemistry, Physics, and Earth Science. These are further divided into topics and specific assessment objectives.[9] There are 18 topics and 50 objectives. For more information, see appendix table A-4 and the 2011 TIMSS grade 8 science framework.[10]

Table 2 illustrates how each framework organizes the science content and the target percentages of the assessment devoted to each content area. The framework targets in science for both NAEP and TIMSS are in terms of the percentages of assessment time.

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[6] The NAEP science assessment specifications document can be accessed at *http://www.nagb.org/publications/frameworks/science/2009-science-specification.html*.
[7] The NAEP science framework can be accessed at http://www.nagb.org/content/nagb/assets/documents/publications/frameworks/science-2011.pdf.
[8] The TIMSS content domains are analogous to the NAEP content areas.
[9] The TIMSS science objectives are analogous to the NAEP science content statements.
[10] The TIMSS science framework can be accessed at http://timssandpirls.bc.edu/timss2011/downloads/TIMSS2011_Frameworks.pdf.

Note that Physics and Chemistry are distinct content domains in TIMSS, but are combined into Physical Science in NAEP. In terms of assessment time, NAEP places more emphasis at grade 8 on Earth and Space Sciences (40 percent), while TIMSS places more emphasis on Physical Science (45 percent).

Table 2. NAEP and TIMSS science framework targets for grade 8, by content area/domain: 2011

NAEP science framework		TIMSS science framework	
Content area	**Target percent**	**Content domain**	**Target percent**
Life Science	30	Biology	35
Physical Science	30	Physics	25
		Chemistry	20
Earth and Space Sciences	40	Earth Science	20

NOTE: The target percentages by NAEP content area and TIMSS content domain are both for the percentage of assessment time. Physics and Chemistry are distinct content domains in TIMSS, but are combined into Physical Science in NAEP.
SOURCE: National Assessment Governing Board, *Science Framework for the 2011 National Assessment of Educational Progress,* 2010; and International Association for the Evaluation of Educational Achievement, *TIMSS 2011 Assessment Frameworks, 2009.*

Science Cognitive Dimension

The NAEP science framework describes the cognitive dimension in terms of four science practices, with the following distribution of assessment time:

- Identifying Science Principles (25 percent);
- Using Science Principles (35 percent);
- Using Scientific Inquiry (30 percent); and
- Using Technological Design (10 percent).

The TIMSS science framework defines the cognitive dimension in terms of three cognitive domains, with the following distribution of assessment time:

- Knowing (35 percent);
- Applying (35 percent); and
- Reasoning (30 percent).

In NAEP, the science practices describe the ways in which science knowledge is used across the content areas. When combined with the content statements, the science practices define a range of performance expectations to measure what students know and

are able to do with the specific science content in the framework.

Identifying Science Principles focuses on the ability to recognize, recall, define, relate, and represent basic science principles. Using Science Principles focuses on the application of science knowledge to predict, explain, reason with models, and solve problems. Using Scientific Inquiry involves applying science knowledge and skills to answer a question under investigation, focusing on designing and conducting investigations, analyzing data, and using evidence to validate or criticize conclusions. Using Technological Design involves the systematic process of applying science knowledge to propose or critique solutions to real-world problems, including identifying trade-offs and anticipating the effects of design decisions.

TIMSS uses the same cognitive domains for science as for mathematics, although the specific skills and abilities associated with each category differ across the two subjects. Similar to the way they are used the mathematics framework, when used in a scientific context, the cognitive domains articulate specific expectations of how students use scientific knowledge. Students are expected to demonstrate knowledge of science facts, procedures, and concepts (Knowing); to apply knowledge and conceptual understanding to solve problems and develop explanations (Applying); and to engage in scientific reasoning to analyze and solve more complex problems, apply knowledge to unfamiliar situations, hypothesize, and draw conclusions from investigations (Reasoning).

The next sections of the report describe the methodology used in the study, followed by the results and conclusions. The results are presented separately for mathematics and science.

Methodology

Expert Panels

Two expert panels were assembled to compare the NAEP and TIMSS frameworks—one for mathematics and one for science. Each panel consisted of six subject area curriculum and assessment experts with experience working with framework and item development for NAEP and/or TIMSS. At least one member of each panel served on the writing team for either the TIMSS or NAEP framework in the respective subject area. In addition, each panel member:

- has served, or is currently serving, on a NAEP and/or TIMSS expert panel in mathematics or science;
- is familiar with the 2011 NAEP framework and/or 2011 TIMSS framework as well as the respective assessment(s);
- has experience writing or reviewing mathematics or science curriculum and assessment standards at the local, state, national, and/or international levels; and
- has experience working with eighth-grade frameworks and assessments.

The names and affiliations of the expert panelists are listed in appendix B.

Procedures

In advance of the expert panel meetings, staff from the American Institutes for Research (AIR) prepared two working documents (one for mathematics and one for science) that initially aligned the objectives/content statements in the NAEP and TIMSS frameworks.[11] As part of the alignment, some objectives appeared only in the NAEP framework, while others appeared only in the TIMSS framework. In some cases, it was possible to group a single objective from one framework with a single objective from the other framework. In other cases, a single objective from one framework was grouped with multiple objectives from the other framework.

[11] In addition to comparing the NAEP and TIMSS frameworks, AIR staff examined the NAEP assessment specification documents for mathematics and science (National Assessment Governing Board 2007a and 2007b). These companion documents contain much of the same information found in the frameworks, but give more detail about the development of the items and conditions for the assessments, along with additional information that clarifies the objectives to be assessed. Unless otherwise stated, the contents of these companion documents are assumed to be included in all references to the frameworks throughout this report.

The expert panel meetings were convened in Washington, DC, in October 2012. The meetings were one-and-a-half days long. Both meetings began with AIR staff providing an overview of the NAEP and TIMSS frameworks for mathematics/science. Next, the panelists were introduced to the rating scale shown in exhibit 1, which was used to evaluate the comparability of the grade 8 mathematics and science content defined by the 2011 NAEP and TIMSS frameworks:

Exhibit 1. Rating scale for evaluating the comparability of the 2011 NAEP and TIMSS grade 8 frameworks

Rating	Definition
4	Exactly or almost the same
3	Quite similar, but with some differences
2	Quite dissimilar, but with some overlap
1	Substantially or wholly different

For each comparison that was made, the panelists were asked the following question:

> "How similar are the knowledge and skills being described by the NAEP (mathematics/science) framework to the knowledge and skills being described by the TIMSS (mathematics/science) framework?"

As part of the training, the panelists rated a practice set of objectives/content statements that were similar to those in the respective frameworks to ensure consistency in the use of the rating scales.[12]

Following the training, the panelists were presented with the preliminary groupings of objectives that had been prepared by AIR staff. The panelists discussed the preliminary groupings and revised some by consensus. The panel members then evaluated the degree of comparability of the objectives in each grouping. First, the panelists independently used the 4-point rating scale to assign a preliminary rating to each pair or group of objectives, one at a time. Any objective that appeared in only one framework was automatically assigned a rating of 1 ("substantially or wholly different"). Second, after assigning each preliminary rating, the panelists discussed their ratings with the group. Finally, following the discussion, the panelists independently used the 4-point scale to assign a final rating to each pair or group of objectives. The ratings from this final round of coding were used in the analyses.

[12] No formal analyses of inter-rater agreement were performed.

After completing the rating of all grouped objectives, panelists were asked to evaluate the comparability of each content area as a whole, for mathematics and science, respectively. Once again, the panelists independently used the 4-point rating scale to assign a preliminary rating to each content area. After assigning each preliminary rating, the panelists discussed their ratings with the group. Following the discussion, the panelists independently used the 4-point scale to assign a final rating to each content area. The ratings from this final round of coding were used in the analyses.

After comparing the content dimensions of the frameworks, the panelists spent the remaining time comparing the cognitive dimensions and other features of the frameworks. All six panel members for each subject worked as a group to generate a list of statements to capture the major differences between the two frameworks.

Then, the panelists assigned an overall similarity rating at the framework level, using the 4-point rating scale. The panelists independently rated the extent to which the NAEP and TIMSS frameworks were similar for the given subject.[13]

Analyses

The framework content was defined as "similar" for NAEP and TIMSS when at least four of the six panelists assigned the content a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"), using the rating scale in exhibit 1. When this criterion was not met, the framework content was classified as "not similar."

A rating of "similar" or "not similar" was assigned to every objective/content statement[14] based on the panelists' ratings of the grouped objectives. The same procedures were used to assign a rating of "similar" or "not similar" at the content area level as well as the overall framework level.

[13] The panelists also were asked to use the 4-point rating scale to assign an overall rating of the framework at two other points during the meeting; first, following the ratings of the objectives/content statements; second, following the ratings of the content areas. However, it was the overall ratings that the panelists assigned in the final round that were used in the analyses.

[14] If an objective appeared in more than one grouping, the ratings were weighted to sum to 1 for that objective. For example, if part of an objective appeared in each of two groupings and was rated as "similar" in one grouping and "not similar" in the other grouping, then 0.5 objectives would count toward the total number of "similar" objectives, and 0.5 objectives would count toward the total number of "not similar" objectives.

To complement the quantitative analyses, the objectives/content statements were organized into topics using content comparison tables to show how the framework content was similar or not similar. From the objectives presented to the expert panels, any topic that appeared in only one framework was automatically assigned a 1 (“substantially or wholly different”). In the content comparison tables, these topics were identified as belonging only to the NAEP or TIMSS framework. When grouped objectives appeared in both frameworks, they were identified as “similar” or “not similar” using the same criteria detailed above (i.e., based on whether or not at least four of the six panelists assigned them a rating of 3 or 4 on the 4-point scale). Summary statements indicate the ways in which each topic in the content comparison tables is similar or not similar in the two frameworks.

Mathematics Results

The results of the mathematics framework comparisons follow, along with specific examples of similarities and differences in the framework content and other framework dimensions (e.g., the cognitive domain). When reading the results, it is important to remember that the 2011 NAEP and TIMSS grade 8 frameworks describe potential content for item development in each of the mathematical content areas. The similarities and differences in the knowledge and skills described in the frameworks may not be fully reflected in the resulting 2011 grade 8 assessment items.

Table 3 summarizes the extent to which the NAEP objectives are similar to those in the TIMSS framework and the TIMSS objectives are similar to those in the NAEP framework. Seventy percent of the NAEP mathematics objectives were judged as having similar objectives in the TIMSS framework. Eighty-five percent of the TIMSS mathematics objectives were judged as having similar objectives in the NAEP framework.

Table 3. Summary of NAEP and TIMSS objectives rated as similar or not similar in grade 8 mathematics frameworks: 2011

	NAEP objectives		TIMSS objectives	
Rating	Number	Percent	Number	Percent
Total	101	100	41	100
Similar	71	70	35	85
Not similar	30	30	6	15

NOTE: A rating of "similar" indicates that at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same").

At the content area level, all of the content areas in the NAEP framework were judged to be similar to the content domains in the TIMSS framework (see table 4). The Geometry and Measurement content areas in NAEP were combined for the purpose of this comparison.

Table 4. Summary of NAEP and TIMSS content areas/domains rated as similar or not similar in grade 8 mathematics frameworks: 2011

NAEP content area	TIMSS content domain	Similarity rating	Summary rating
Number Properties and Operations	Number	6 out of 6	Similar
Geometry/Measurement	Geometry	4 out of 6	Similar
Data Analysis, Statistics, and Probability	Data and Chance	5 out of 6	Similar
Algebra	Algebra	6 out of 6	Similar

NOTE: The *similarity rating* indicates the number of panelists assigning a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"). The *summary rating* is "similar" when at least 4 out of 6 panelists assigned a rating of 3 or 4; otherwise, it is "not similar."

At the framework level, all six panelists assigned a rating of "quite similar, but with some differences," indicating that the NAEP and TIMSS frameworks are similar overall.

A more detailed comparison of the content dimension of the two mathematics frameworks is provided below in exhibits 2, 3, 4, and 5, organized by the NAEP content areas (Geometry and Measurement have been combined). Each exhibit lists mathematics topics that were used to organize groups of NAEP and TIMSS objectives within each content area. The exhibits indicate (1) whether the topic was included in the NAEP framework, the TIMSS framework, or both; and (2) if both, whether the content in the two frameworks was judged to be similar or not similar by the expert panel.

Out of 14 topics in the Number Properties and Operations content area (see exhibit 2), 8 were rated as similar across the two frameworks. Six of the topics, including "Estimation," are present in NAEP only; no topics were present only in the TIMSS framework. Topics that were only included in NAEP were not present in the TIMSS framework at grade 4.

Exhibit 2. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Number Properties and Operations

Topic	Framework	Summary statement
Number properties and place value	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the application of commutative, associative, and distributive properties of operations, although TIMSS restricts the use to whole numbers while NAEP lists no rational number restrictions. The TIMSS framework specifically includes understanding of place value for finite decimals, while the NAEP framework includes integers and decimals.
Interpretation of rational number operations	NAEP only	NAEP includes the interpretation of rational number operations (roots, powers, additive and multiplicative inverses) as well as the understanding of the relationship between them. This concept is not specifically stated in the TIMSS framework.
Effect of multiplication and division on rational numbers	NAEP only	NAEP includes knowledge of the effect of multiplication and division on rational numbers, including the effect of multiplying or dividing a rational number by 0, a number between 0 and 1, or a number greater than 1. This concept is not specifically stated in the TIMSS framework.
Factors, multiples, primes, powers, and roots	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include finding factors and multiples of numbers, identifying prime numbers, and finding square roots of perfect squares from 1 to 144. In addition, the NAEP framework specifically includes identifying perfect cubes (1 through 125), finding the lowest common multiple, prime factorization, using composite numbers to solve problems, and determining between which two whole numbers the square and cube roots of numbers less than 1,000 lie. The TIMSS framework also specifically includes evaluating powers of numbers.
Order and compare rational numbers	NAEP and TIMSS: Similar	Both NAEP and TIMSS include ordering and comparing integers and fractions. The NAEP framework also includes ordering and comparing decimals and percents and emphasizes the comparisons of very large numbers and decimals and fractions close to zero.
Multiple representations of rational numbers	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include recognizing and writing equivalent representations of numbers and converting between fractions, decimals, and percents.
Models and representations of numerical relationships	NAEP and TIMSS: Similar	Using number lines and diagrams to model and represent rational numbers is included in TIMSS and NAEP. The NAEP framework also includes recognizing, translating between, and applying multiple representations of rational numbers.
Computation and problem solving	NAEP and TIMSS: Similar	Rational number computation within and outside of problem-solving contexts is included in both NAEP and TIMSS. In addition, the NAEP framework explicitly includes verifying solutions, determining the reasonableness of results, describing how odd and even integers behave under different operations, providing a mathematical argument to explain operations with two or more fractions, and using divisibility or remainders in problem situations.

Exhibit 2. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Number Properties and Operations—Continued

Ratios, proportions, and percents	NAEP and TIMSS: Similar	Modeling situations and solving problems using ratios, percents, and proportions are included in NAEP and TIMSS. The TIMSS framework does not elaborate on specific models and problem situations, while the NAEP framework specifically includes finding percent increases and decreases, interest rates, tax, scale drawings, conversions within the same measurement system and rates (such as speed or population density).
Absolute value	NAEP only	The NAEP framework includes finding or modeling absolute values and applying absolute values to problem situations. These concepts are not specifically stated in the TIMSS framework.
Rational number and common irrational number benchmarks	NAEP only	NAEP includes applying benchmarks for using rational and common irrational numbers in contexts. Applying benchmarks is not specifically stated in the TIMSS framework.
Estimation	NAEP only	The NAEP framework includes making estimations appropriate to a given situation by identifying when to estimate, determining the level of accuracy needed, selecting an appropriate method of estimation, and analyzing the effect of an estimation method on the accuracy of results. These concepts are not specified in the TIMSS framework.
Justification of a numerical concept	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include explaining or justifying mathematical concepts and numerical relationships.
Scientific notation	NAEP only	Using scientific notation to express or interpret numbers from real-life contexts is included in the NAEP framework, but not the TIMSS framework.

NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Number Properties and Operations content area can be found on pages 7–13 of the NAEP mathematics framework. The Number content domain can be found on pages 30–32 of the TIMSS mathematics framework.

Out of 16 topics in the Geometry and Measurement content area (see exhibit 3), 11 were rated as similar across the two frameworks. Five topics, including "Intersections of geometric figures in the plane" and Cross-sections of solids," were covered in NAEP only; no topics were represented only in the TIMSS framework. Topics present in NAEP only were not present in the TIMSS framework at grade 4.

Exhibit 3. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Geometry and Measurement

Topic	Framework	Summary statement
Geometric properties of angles, lines, and simple geometric shapes	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include the identification of different types of angles and the relationships between angles formed by intersecting lines and angles found in simple geometric shapes such as triangles and quadrilaterals. The NAEP framework explicitly includes the relationship of angles formed by parallel lines cut by a transversal.
Pythagorean Theorem	NAEP and TIMSS: Similar	Applying the Pythagorean Theorem to solve problems is included in both the NAEP and TIMSS frameworks.
Symmetry	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the recognition of line and rotational symmetry. The NAEP framework also includes point symmetry.
Congruence and similarity	NAEP and TIMSS: Similar	Identifying and using the properties of congruence and similarity of triangles and quadrilaterals to solve problems is included in both NAEP and TIMSS. The NAEP framework provides additional specification of properties to include, such as angle conservation and the proportionality of side length and perimeter, as well as solving problems involving direct measurement.
Recognition of, reasoning with, and application of geometric properties of two- and three-dimensional shapes	NAEP and TIMSS: Similar	The NAEP and TIMSS frameworks both include recognizing and using geometric properties of common two- and three-dimensional shapes. While the TIMSS framework does not specify which geometric properties to include, the NAEP framework includes specific contexts in which to recognize or use geometric properties such as drawing a geometric figure given a written description, making and testing a geometric conjuncture about regular polygons, and identifying or describing a geometric shape in a plane or in three-dimensional space given a visual representation.
Two-dimensional representations of three-dimensional figures	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include knowledge of the relationship between a three-dimensional shape and its two-dimensional representation. The NAEP framework explicitly includes views from multiple perspectives and lists specific three-dimensional figures to be included, such as cubes, regular tetrahedrons, and rectangular solids.
Angle, line, perimeter, area, and volume measurement	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include measuring and estimating the size of angles and lengths of line segments. Both also include finding perimeter, area, and volume. The NAEP framework includes specific knowledge of measurement processes and procedures such as the selection of proper measurement tools, determining measurement accuracy, and determining the appropriate size of the unit of measurement. NAEP also includes the comparison of objects with respect to length, area, volume, angle measurement, weight, or mass.
Distance between two points	NAEP only	NAEP includes drawing or describing the path of shortest length between two points to solve contextual problems. These concepts are not specifically stated in the TIMSS framework.
Problem solving using measurement formulas	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include selecting and using formulas for calculating the perimeter, circumference, area, surface area, and volume of simple geometric shapes as well as composite shapes.

Exhibit 3. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Geometry and Measurement—Continued

Rectangular coordinate system	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include identifying points on a rectangular coordinate system and using those points to solve problems. The NAEP framework includes specific applications of this knowledge, including graphing and interpreting rational number points listed as ordered pairs and representing geometric figures using rectangular coordinates. Describing relative positions of points and lines using the ideas of midpoint, parallelism, and perpendicularity are also specifically identified in NAEP.
Geometric transformations	NAEP and TIMSS: Similar	The recognition of simple transformations of two-dimensional geometric shapes including translation, reflection, and rotation is included in both frameworks. The NAEP framework also includes magnification and contraction.
Measurement unit selection	NAEP only	The NAEP framework includes selecting appropriate units for various types of measurement, such as area, length, angle, time, and volume. The selection of appropriate measurement units is not included in the TIMSS framework.
Combinations and decompositions of two- and three-dimensional shapes	NAEP only	The NAEP framework includes predicting the results of combining, subdividing, and changing the shapes of plane figures and solids such as paper folding, tiling, and cutting up and rearranging pieces. These examples, along with making predictions about solids, are not specifically included in the TIMSS framework.
Problem solving using geometric models	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include solving problems using geometric models.
Intersections of geometric figures in the plane	NAEP only	The NAEP framework includes describing the intersection of two or more figures in the plane, such as the intersection of a circle and a line, something which is not specified in the TIMSS framework.
Cross-sections of solids	NAEP only	Visualizing and describing the cross-section of a solid is included in the NAEP framework, but is not specified in the TIMSS framework.

NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Measurement content area can be found on pages 13–17 of the NAEP mathematics framework; the Geometry content area can be found on pages 18–23 of the NAEP mathematics framework. The Geometry content domain can be found on pages 34–36 of the TIMSS mathematics framework.

Out of 10 topics in the Data Analysis, Statistics, and Probability content area (see exhibit 4), four were rated as similar across the two frameworks. The topic of "Probability" was rated as being present in both frameworks, but in a way that was not similar. Four of the topics, including "Line of best fit" and "Sample bias," are covered in NAEP only; one topic, "Chance of an outcome (likely, certain, impossible)," is only in the TIMSS framework. Although not included explicitly at grade 8, NAEP does include probabilistic thinking to

describe chance at grade 4. In addition, pictographs are present in the TIMSS framework at grade 8, but only at grade 4 in the NAEP framework.

Exhibit 4. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Data Analysis, Statistics, and Probability

Topic	Framework	Summary statement
Organization, interpretation, and use of data displays	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include reading and interpreting data from various types of data displays to solve problems. Both frameworks include tables, bar graphs, circle graphs or pie charts, and line graphs to organize and display data. NAEP also includes the following data representations: frequency distributions, histograms, stem and leaf plots, and box plots. The TIMSS framework also includes pictographs.[1]
Line of best fit	NAEP only	Choosing a line of best fit given a scatterplot and informally explaining the meaning of the line, or using the line to make predictions, is included in the NAEP framework, but not the TIMSS framework.
Multiple representations of a dataset	NAEP and TIMSS: Similar	Comparing different representations of the same dataset is included in both the NAEP and TIMSS frameworks.
Characteristics of datasets (mean, median, mode, range)	NAEP and TIMSS: Similar	The NAEP and TIMSS frameworks include calculating and comparing characteristics of datasets. This includes the mean, median, mode, range, and shape of a data distribution, as well as comparing the same characteristic of two different datasets. The NAEP framework also includes outliers and their effect on the measures of central tendency and range, which is not explicitly included in the TIMSS framework.
Effective data representation	NAEP and TIMSS: Similar	Determining effective and misleading approaches to displaying data is included in both the NAEP and TIMSS frameworks. The TIMSS framework includes examples of misinterpretation, such as inappropriate data groupings or distorted scales, while the NAEP framework includes examples of data displays, such as line graphs, scatterplots, circle graphs, and bar graphs.
Chance of an outcome (likely, certain, impossible)	TIMSS only	The TIMSS framework includes judgment of the chance of an outcome as either certain, more likely, equally likely, less likely, or impossible.[2]
Probability	NAEP and TIMSS: Not Similar	Both the NAEP and TIMSS frameworks include the closely related concepts of probability and chance, specifically using the chance of a particular outcome to solve problems. However, the NAEP framework uses a more formal approach to describing probability concepts and procedures, such as determining the theoretical probability of both simple and compound events, determining the probability of both independent and dependent events, determining the sample space, and representing the probability of an outcome using fractions, decimals, and percents.
Sample bias	NAEP only	Identifying possible sources of bias in sampling is a concept included in the NAEP framework, but not the TIMSS framework.

Exhibit 4. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics frameworks: Data Analysis, Statistics, and Probability—Continued

Random and nonrandom samples	NAEP only	The NAEP framework includes distinguishing between a random and nonrandom sample. The concept is not included in the TIMSS framework.
Evaluate the design of an experiment	NAEP only	The NAEP framework includes evaluating the design of an experiment, but the concept is not included in the TIMSS framework.

[1] Pictographs are included in the NAEP framework at grade 4.
[2] The use of informal probabilistic thinking to describe chance events (such as identifying the chance of an outcome as likely, unlikely, or certain) is included in the NAEP framework at grade 4.
NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Data Analysis, Statistics, and Probability content area can be found on pages 24–30 of the NAEP mathematics framework. The Data and Chance content domain can be found on pages 36–38 of the TIMSS mathematics framework.

Out of 12 topics in the Algebra content area (see exhibit 5), 7 were rated as similar across the two frameworks. Two topics, "Evaluate and use formulas" and "Problem solving using functions, equations, and inequalities," were rated as being present in both frameworks, but in a way that was not similar. Three topics, including "Calculation of slope and intercepts in linear functions," are present in NAEP only; no topics were present only in the TIMSS framework. "Solving a system of two-variable linear equations" is a concept included in the grade 8 framework of TIMSS, but is not included until grade 12 in the NAEP framework.

Exhibit 5. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics framework: Algebra

Topic	Framework	Summary statement
Patterns and sequences	NAEP and TIMSS: Similar	Recognizing, describing, extending, and generalizing numerical and geometric patterns using tables, graphs, symbols, or words is included in both the NAEP and TIMSS frameworks. The TIMSS framework specifically includes generalizing pattern relationships in a sequence, between adjacent terms, or between the sequence number of the term and the term, while the NAEP framework specifically includes analyzing or creating patterns, sequences, or linear functions given a rule.
Operations with algebraic expressions	NAEP and TIMSS: Similar	Performing basic operations on algebraic expressions is included in both NAEP and TIMSS. The TIMSS framework includes finding sums, products, and powers of expressions containing variables, and simplifying or comparing algebraic expressions to determine if they are equal. The NAEP framework includes performing operations on linear algebraic expressions including grouping and order of multiple operations, simplifying and expanding expressions, and the use of exponents and roots.
Algebraic representations using expressions	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include writing an expression to represent a given situation. The NAEP framework restricts expressions to include linear and simple quadratic expressions in contextual situations; no such restriction is included in the TIMSS framework.
Evaluate and use formulas	NAEP and TIMSS: Not Similar	Both the NAEP and TIMSS frameworks include evaluating formulas; however, there are distinct differences in the way that this concept is addressed in each framework. In the NAEP framework, the formula must be used within common contextual situations. In TIMSS, the focus is on evaluating equations given values of the variables and determining whether a value satisfies a given formula. The TIMSS framework does not specifically state that evaluation of formulas must be from contextual situations.
Linear equations and inequalities	NAEP and TIMSS: Similar	Both NAEP and TIMSS include solving linear equations or inequalities. TIMSS also includes solving simultaneous (two-variable) linear equations.[1]
Algebraic representations using equations and inequalities	NAEP and TIMSS: Similar	The NAEP and TIMSS frameworks both include recognizing or writing equations or inequalities to represent a given situation.
Properties of functions	NAEP only	The NAEP framework specifically includes the identification of functions as linear or nonlinear. Also included is contrasting distinguishing properties of functions from tables, graphs, or equations. The TIMSS framework does not specifically include these concepts.
Representations of functions	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include recognizing and generating representations of functions using tables, graphs, or words. The NAEP framework is very specific on the types of functional relationships to emphasize: proportional, linear, and common nonlinear, such as compound interest or bacterial growth.

Exhibit 5. Content comparison of 2011 grade 8 NAEP and TIMSS mathematics framework: Algebra—Continued

Problem solving using functions, equations, and inequalities	NAEP and TIMSS: Not Similar	Both the NAEP and TIMSS frameworks include solving problems using equations and formulas. However, the NAEP framework includes only linear equations and inequalities with rational coefficients. No such restriction is specifically stated in the TIMSS framework. In addition, NAEP includes the interpretation of the equals sign as an equivalence between two algebraic expressions and the use of the interpretation to solve problems. These concepts are not included in the TIMSS framework. The NAEP framework also specifically states that both graphical and symbolic solutions are to be included.
Algebraic reasoning with linear relationships	NAEP and TIMSS: Similar	The NAEP and TIMSS frameworks both include making, validating, justifying, and generalizing conclusions about linear relationships.
Interpretation of slope and intercepts in linear functions	NAEP only	The NAEP framework includes the interpretation of the meaning of slope and intercepts in linear functions, while the TIMSS framework does not.
Calculation of slope and intercepts in linear functions	NAEP only	The NAEP framework explicitly includes interpreting relationships between symbolic linear expressions and graphs of lines by identifying and computing slope and intercepts. The TIMSS framework does not specifically include these concepts.

[1] Solving a system of two linear equations is included in the NAEP framework at grade 12.
NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Algebra content area can be found on pages 30–36 of the NAEP mathematics framework. The Algebra content domain can be found on pages 32–33 of the TIMSS mathematics framework.

After comparing the content dimensions of the frameworks, the expert panel spent the remaining time comparing the cognitive dimensions and other features of the mathematics frameworks. All six panel members worked as a group to generate the following list of statements to capture the major differences between the two frameworks:

- The NAEP framework defines the cognitive dimension using levels of complexity: low, moderate, and high**.** The levels are hierarchical and are intended to place an ordered description of demands on student thinking. Levels of complexity are not dependent on the mathematical content expectations of the item or on the item type.
- The TIMSS mathematics framework refers to the cognitive dimension by using three cognitive domains: Knowing, Applying, and Reasoning. The TIMSS approach

classifies cognitive demand by trying to capture the cognitive processes that the student may need to apply to solve the problem.

- While there is some relationship between levels of complexity in the NAEP framework and cognitive demand in the TIMSS framework, especially at the low and high levels of cognitive demand, the two dimensions are not interchangeable. For example, assessment items in the TIMSS "Applying" domain could be classified as either of low or moderate complexity in NAEP. An examination of the relationship between the content and the cognitive demand within individual items from the two item pools is needed to further illustrate the differences between the two frameworks.
- It is not possible to compare the percentages of items classified by the cognitive dimensions of the two frameworks because of the inability to directly map the TIMSS cognitive domains to a specific level of complexity within the NAEP framework.
- The Number Properties and Operations content area in the NAEP framework is organized by number topics, such as number sense and number operations. The Number content domain in the TIMSS framework is organized by types of numbers, such as whole numbers, fractions, and decimals.
- The NAEP framework allows for the use of calculators on approximately one-third of the assessment, while the TIMSS framework allows for the use of calculators on the entire assessment.[15] However, TIMSS items are developed with the understanding that the use of calculators should not provide an advantage to students who use them.
- The NAEP framework provides explicit guidelines on the use of measurement attributes, tools, instruments, geometric formulas, and conversions that students are expected to know. The TIMSS framework does not include similar guidelines.

[15] The decision of whether or not to allow calculators on TIMSS is at the discretion of each participating country. The United States does permit calculator use.

Science Results

The results of the science framework comparison follow, along with specific examples of similarities and differences in the framework content and other framework dimensions (e.g., the cognitive domain). When reading the results, it is important to remember that the 2011 NAEP and TIMSS grade 8 frameworks describe potential content for item development in each of the science content areas. The similarities and differences between the knowledge and skills described in the frameworks may not be fully reflected in the resulting assessment items.

Table 5 summarizes the extent to which the NAEP content statements are similar to the TIMSS objectives and the TIMSS objectives are similar to the NAEP content statements. Fifty-six percent of the NAEP science content statements were judged as having similar objectives in the TIMSS framework. Forty-four percent of the TIMSS science objectives were judged as having similar content statements in the NAEP framework.

Table 5. Summary of NAEP and TIMSS content statements/ objectives rated as similar or not similar in grade 8 science frameworks: 2011

	NAEP content statements		TIMSS objectives	
Rating	Number	Percent	Number	Percent
Total	43	100	50	100
Similar	24	56	22	44
Not similar	19	44	28	56

NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar."

At the content area level, Life Science in NAEP was judged to be similar to Biology in TIMSS based on the alignment of the objectives between the two frameworks (see table 6). However, the Physical Science content area in NAEP was judged to be not similar to the Physics and Chemistry content domains in TIMSS. The Earth and Space Sciences content area in NAEP also was judged to be not similar to the Earth Science content domain in TIMSS.

Table 6. Summary of NAEP and TIMSS content areas/domains rated as similar or not similar in the grade 8 science frameworks: 2011

NAEP content area	TIMSS content domain	Similarity rating	Summary rating
Life Science	Biology	4 out of 6	Similar
Physical Science	Physics	1 out of 6	Not similar
	Chemistry	0 out of 6	Not similar
Earth and Space Sciences	Earth Science	2 out of 6	Not similar

NOTE: The *similarity rating* indicates the number of panelists assigning a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"). The *summary rating* is "similar" when at least 4 out of 6 panelists assigned a rating of 3 or 4; otherwise, it is "not similar."

At the very end of the panel meeting, following a group discussion, panelists assigned a summary rating to compare the NAEP and TIMSS science frameworks. At the overall framework level, four out of six panelists assigned a rating of "quite similar, but with some differences," while two panelists assigned a rating of "quite dissimilar, but with some overlap." According to the predetermined criteria, these ratings indicate that the NAEP and TIMSS science frameworks are similar overall.

Cross-cutting content is an explicit part of the NAEP science framework, with some related concepts included in multiple content areas. For example, subtopics and content statements related to matter and energy transformations and conservation are included across Life Science, Physical Science, and Earth and Space Sciences. Also, the biogeochemical cycles subtopic draws on knowledge of science principles from all three content areas. The inclusion of crosscutting content in the NAEP framework is intended to permit the development of item sets from across the content areas that can measure these concepts in greater depth. This results in some differences between the two frameworks in the alignment of specific topics within and across the content areas. Some concepts or topics in the TIMSS science framework (particularly in Physics and Chemistry) are included at a different grade in the NAEP science framework, although the specific expectations would be different. The NAEP science framework includes hands-on performance tasks and interactive computer tasks in addition to the paper-and-pencil component. Calculators are allowed for the TIMSS science assessment,[16] but not for the NAEP science assessment.

A more detailed comparison of the content dimension of the two science frameworks is provided below in exhibits 6, 7, and 8, organized by the NAEP content areas. Each table

[16] The decision of whether or not to allow calculators for the TIMSS science assessment is made by each participating country.

lists science topics that were used to organize groups of NAEP content statements and TIMSS objectives within each content area. The exhibits indicate (1) whether the topic was included in the NAEP framework, the TIMSS framework, or both; and (2) if both, whether the content in the two frameworks was judged to be similar or not similar by the expert panel.

Out of 16 topics in the Life Science content area (see exhibit 6), 9 were rated as similar across the two frameworks. Four topics were rated as being present in both frameworks, but in a way that was not similar. There were no topics covered only in NAEP; however, there were three topics that were represented only in the TIMSS framework. One of these topics, “Growth and development of organisms,” is included only in the TIMSS framework at grade 8. However, the topic of life cycles of different organisms is included in the NAEP framework at grade 4.

Exhibit 6. Content comparison of 2011 grade 8 NAEP and TIMSS science frameworks: Life Science

Topic	Framework	Summary statement
Classification and relatedness of organisms	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include the classification of organisms based on physical characteristics. However, there are some differences in the focus and level of specificity in the frameworks. NAEP focuses on anatomical similarities used to infer degree of relatedness and the importance of internal and external structures, while TIMSS focuses on defining characteristics that differentiate among major taxonomic groups and subgroups.
Role of organs and organ systems	NAEP and TIMSS: Not Similar	While both NAEP and TIMSS include the role of organs and organ systems in carrying out life functions in organisms, TIMSS has more focus on humans (e.g., locating major organs in the human body and comparing organ systems in humans and other organisms). The NAEP framework places more focus on the role of organ systems to serve the needs of cells.
Concept and examples of homeostasis	TIMSS only	TIMSS includes the concept and some examples of homeostasis (biological actions in response to external and internal changes to maintain stable body conditions), such as sweating and shivering to maintain body temperature and increased heart rate during exercise. This concept is not explicitly included in the NAEP framework.
Cells and their functions	NAEP and TIMSS: Similar	Both NAEP and TIMSS include knowledge of the cellular composition of organisms (tissues, organs, and organ systems), cell division, and specialized cell functions. NAEP also explicitly includes one-celled versus multi-celled organisms, cell differentiation following fertilization to form basic tissues of an embryo, and knowledge that water accounts for about two-thirds of cell weight. TIMSS explicitly includes cell structures and functions of cell organelles as well as comparisons between plant and animal cells.
Photosynthesis and cellular respiration	NAEP and TIMSS: Similar	The basic processes of photosynthesis and cellular respiration are included in both the NAEP and TIMSS frameworks. Both frameworks include photosynthesis requiring light, carbon dioxide, and water to produce food and release oxygen. Both frameworks also include the breakdown of food to provide energy for cells. In addition, NAEP explicitly includes details of how plants use sugars to form fats, proteins, and carbohydrates. The TIMSS framework explicitly describes cellular respiration (the need for oxygen and release of carbon dioxide) and the role of chlorophyll in photosynthesis.
Growth and development of organisms	TIMSS only	The TIMSS framework includes comparing how different organisms grow and develop. In contrast, the NAEP framework focuses on reproduction as part of the life cycle of all organisms, rather than on growth and development.[1]
Sexual and asexual reproduction	NAEP and TIMSS: Similar	Both NAEP and TIMSS include sexual and asexual reproduction. Both frameworks include comparisons at the cellular level—asexual reproduction from cell division to produce identical offspring and sexual reproduction uniting sperm and egg to produce offspring with traits from both parents. In addition, NAEP describes reproduction as a characteristic of all living systems that is essential for the continuation of all living species.

Exhibit 6. Content comparison of 2011 grade 8 NAEP and TIMSS science frameworks: Life Science—Continued

Inheritance of traits	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the concept of inheritance of traits and organisms passing on genetic material to their offspring. Distinguishing between inherited and acquired characteristics is included in both frameworks. NAEP explicitly describes interactions with the environment as important for some characteristics.
Diversity, adaptation, and natural selection	NAEP and TIMSS: Similar	Both NAEP and TIMSS include concepts related to diversity, adaptation, and natural selection. At grade 8, this topic includes how the survival and extinction of species are related to variations in characteristics in populations and reproductive success in changing environments.
Fossil evidence for the history of and changes in organisms over time	NAEP and TIMSS: Similar	Both the NAEP and TIMSS frameworks include the concept that fossils provide evidence for the history of and changes in organisms over time, including the extinction of species. In NAEP, this is cross-cutting content in Life Science and Earth and Space Sciences.
Energy flow in ecosystems	NAEP and TIMSS: Similar	Both NAEP and TIMSS include energy flow in ecosystems, including the role of producers, consumers, and decomposers and the interpretation of food webs and energy pyramids. NAEP includes light from the sun as the source of energy for producers as cross-cutting content in Life Science, Physical Science, and Earth and Space Sciences.
Role of organisms in the cycling of matter in ecosystems	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include the role of organisms in the cycling of elements and compounds (e.g., oxygen, carbon, water) in ecosystems. However, NAEP includes more specifics about the sequence of transformations of matter in producers, consumers, and decomposers (e.g., plants using sugars to form fats, proteins, and carbohydrates that can be used or stored and consumers breaking down structures of organisms they eat).
Interdependence of populations of organisms	NAEP and TIMSS: Similar	Both NAEP and TIMSS include interdependence of populations or organisms in an ecosystem, including producer/consumer and predator/prey relationships and the effects of competition. In addition, NAEP includes parasite/host relationships and mutually beneficial relationships.
Effects of abiotic and biotic factors and environmental changes on populations	NAEP and TIMSS: Similar	Both NAEP and TIMSS include biotic and abiotic factors that limit population size and the effects of environmental changes on the balance of populations in an ecosystem (e.g., predators, food resources, climate, water supply, population changes).
Impact of humans on ecosystems	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include the impact of humans on ecosystems, but the focus and specific content differ. TIMSS focuses on the causes and effects of human population growth in biology. NAEP includes the human impact on plant and animal populations as cross-cutting content in the biogeochemical cycles topic in Earth and Space Sciences.

Exhibit 6. Content comparison of 2011 grade 8 NAEP and TIMSS science frameworks: Life Science—Continued

Human health, nutrition, and disease	TIMSS only	The topic of human health, nutrition, and disease is explicitly included in the TIMSS framework. This topic includes concepts related to infection and transmission of disease; the immune system; the role of diet, exercise, and lifestyle; and specific nutrients. This topic is not included in the NAEP framework.

[1] Life cycles of different organisms is a topic included in the NAEP framework at grade 4.
NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Life Science content area can be found on pages 36–46 of the NAEP science framework. The Biology content domain can be found on pages 64–68 of the TIMSS science framework.

Out of 27 topics in the Physical Science content area (see exhibit 7), 5 were rated as similar across the two frameworks. Eight topics were rated as being present in both frameworks, but in a way that was not similar. Three topics were covered only in NAEP, including "The periodic table." In comparison, 11 topics were represented only in the TIMSS framework (5 from the Chemistry content domain and 6 from the Physics content domain). Many of the topics that were excluded from the grade 8 framework in either assessment were present in other grades of the frameworks. For example, the topic of "Subatomic particles and basic atomic structure" is included in the TIMSS framework for grade 8. This concept is not included in NAEP at grade 8, but it is included at grade 12.

Exhibit 7. Content comparison of 2011 grade 8 NAEP and TIMSS Science frameworks: Physical Science (including Physics and Chemistry)

Topic	Framework	Summary statement
Physical and chemical properties of substances	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the knowledge that substances (elements and compounds) have characteristic physical and chemical properties (e.g., melting and boiling point, density, color, thermal and electrical conductivity, solubility, and magnetic properties) and can be classified or grouped based on these properties. Properties that distinguish metals from nonmetals are included in both frameworks.
The periodic table	NAEP only	Knowledge of the periodic table and how it organizes elements into families with similar properties is explicitly included in the NAEP framework, but not the TIMSS framework.
Particulate structure of matter	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include knowledge of the particulate structure of matter (atoms and molecules), but there are differences in how this is described in the frameworks. Describing the structure of matter in terms of particles, including molecules as combinations of atoms, is explicitly included in a TIMSS Chemistry objective. In NAEP, the particle model (molecules and atoms) is incorporated across multiple content statements related to chemical and physical properties of matter.
Subatomic particles and basic atomic structure	TIMSS only	TIMSS includes knowledge of subatomic particles and basic atomic structure (electrons surrounding a nucleus containing protons and neutrons).[1]
Relating chemical properties of substances to the arrangement of atoms and molecules	NAEP only	While both NAEP and TIMSS include the particulate structure of matter (atoms and molecules), only the NAEP framework explicitly includes the knowledge that chemical properties of substances are explained by the arrangement of atoms and molecules.
Differentiating between pure substances (elements and compounds) and mixtures	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include knowledge of the composition of pure substances (elements composed of a single kind of atom and compounds composed of two or more different elements). In addition, TIMSS explicitly includes differentiating between pure substances and mixtures (homogeneous and heterogeneous) based on their formation and composition.[2]
Solutions and methods for separating mixtures into their components	TIMSS only	The TIMSS framework includes knowledge of solutions and physical methods for separating mixtures into their components (e.g., filtration, distillation, dissolution). This includes concepts related to concentration, solvents and solutes, and factors affecting the rate of dissolving substances. These concepts are not explicitly included in the NAEP framework, although dissolving as a physical change explained by a particle model is included.
Relating the behavior and uses of water to its unique physical properties	TIMSS only	TIMSS includes relating the behavior and uses of water to its physical properties (melting and boiling point, dissolves many substances, thermal properties, expansion upon freezing). The unique properties of water are not a focus in the NAEP framework.

Exhibit 7. Content comparison of 2011 grade 8 NAEP and TIMSS Science frameworks: Physical Science (including Physics and Chemistry)—Continued

Acids and bases	NAEP and TIMSS: Similar	Both NAEP and TIMSS include common properties of acids (e.g., sour taste, color change with acid/base indicators) and knowledge of neutralization reactions of acids and bases. TIMSS also explicitly includes common properties of bases (e.g., bitter taste and slippery feel), the solubility of both acids and bases in water, and the corrosive nature of strong acids and bases. NAEP explicitly describes reactions of acids and bases to produce a salt and water.
Chemical change	NAEP and TIMSS: Similar	Knowledge of chemical change is included in both NAEP and TIMSS. Both frameworks include transformation of substances (reactants and products), evidence of chemical change, conservation of matter and mass, and differentiating between chemical and physical change.
Chemical reactions that release energy or absorb energy	TIMSS only	The TIMSS framework explicitly includes examples and evidence of chemical reactions that release energy or absorb energy. While NAEP includes temperature change and thermal energy associated with chemical changes, classification of exothermic and endothermic reactions is not explicitly included at grade 8.[3]
Common oxidation reactions	TIMSS only	The TIMSS framework includes a Chemistry objective on common oxidation reactions (combustion, rusting, tarnishing) that includes the need for oxygen and ordering familiar substances by how readily they undergo these reactions. While the NAEP framework includes common examples of chemical change and some chemical properties of metals (e.g., reacting with nonmetals to produce salts), it does not include a specific focus on oxidation reactions as in the TIMSS framework.
Physical properties of the different states of matter explained by a particle model	NAEP and TIMSS: Similar	Both NAEP and TIMSS include a model of particles in motion to explain the physical properties of the different states of matter (solids, liquids, and gases).
Changes of state explained by a particle model	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include changes of state explained by a model of particles in motion and the conservation of mass during physical change. However, there are some differences in focus and level of specificity. NAEP is focused on explanations at the atomic/molecular level, including that the structure of atoms and molecules does not change. The TIMSS framework includes more explicit connections to temperature, including that temperature remains constant during changes of state. TIMSS also explicitly describes physical factors that affect the rate or extent of changes of state (e.g., surface area, dissolved substances, temperature).
Relationship between temperature, speed of particles, and changes in volume and/or pressure	NAEP and TIMSS: Not Similar	TIMSS explicitly includes relating temperature changes to the speed of particles and changes in volume and/or pressure. While NAEP includes the use of the particle model to explain physical changes (e.g., changes of state, thermal expansion), the framework is less explicit about the specific relationship between temperature, volume, and pressure.

Exhibit 7. Content comparison of 2011 grade 8 NAEP and TIMSS Science frameworks: Physical Science (including Physics and Chemistry)—Continued

Forms of energy, energy transformations, and conservation of total energy	NAEP and TIMSS: Not Similar	Forms of energy, energy transformations, and conservation of total energy are included in both NAEP and TIMSS. Both include transformations between mechanical (kinetic and potential), electrical, chemical, light, and sound energy as well as different types of thermal energy transfer (conduction, convection, and radiation). However, NAEP describes three forms of potential energy (gravitational, chemical, and elastic) and includes the concept of heat loss to the environment during energy transfer, which is not explicitly stated in the TIMSS framework.
The sun as Earth's primary source of energy	NAEP only	NAEP includes the sun as Earth's primary source of energy as cross-cutting content in Physical Science and Earth and Space Sciences. This includes knowledge that nuclear reactions in the sun produce energy.[4]
Waves and energy transfer	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include light and sound as forms of energy. However, only NAEP explicitly includes different types of waves (light, sound, seismic, water) and the general concept that waves have energy and transfer energy.
Characteristics and properties of light	TIMSS only	The TIMSS framework includes basic characteristics and properties of light and resulting phenomena (e.g., speed of light, ray diagrams, lenses, reflection and absorption, refraction, dispersion, color perception, shadows).[5]
Characteristics and properties of sound	TIMSS only	TIMSS includes basic characteristics (loudness, pitch, amplitude, frequency) and properties of sound, including concepts related to transmission, reflection, absorption, and relative speed through different media. The NAEP framework includes sound waves in the assessment of energy transfer.[6]
Electrical circuits	TIMSS only	Electrical circuits are included in the TIMSS framework. This topic includes diagrams representing the flow of current in complete circuits (series and parallel), conductors and insulators, and the relationship between current and voltage.[7]
Properties and uses of magnets	TIMSS only	TIMSS includes properties and uses of magnets (permanent and electromagnets) and effects of magnetic force. Magnetic force is included in the NAEP grade 8 framework topic related to forces.[8]
Motion of objects	NAEP and TIMSS: Similar	The motion of objects is included in both NAEP and TIMSS. This topic covers descriptions of position, direction, and speed. The NAEP framework also explicitly describes the use and interpretation of motion graphs (position and speed as a function of time).
Forces affecting motion	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include forces affecting motion, but there are some differences in the level of coverage. Both frameworks include general types of forces (e.g., contact force, gravity, friction). However, NAEP is more explicit in terms of forces that act at a distance (magnetic, electrical, and gravitational) and TIMSS explicitly includes buoyant force. Both NAEP and TIMSS include predicting changes in motion based on forces, but the NAEP framework more explicitly describes these concepts, including the magnitude and direction of forces, additive forces, and the effects of net force (zero and nonzero) on motion (speed and direction).

Exhibit 7. Content comparison of 2011 grade 8 NAEP and TIMSS Science frameworks: Physical Science (including Physics and Chemistry)—Continued

Density differences and resulting phenomena	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include density as a physical property of materials and that density differences can be calculated (mass/volume) or observed (e.g., floating or sinking objects, rising balloons). However, there are differences in how this is described in the frameworks. TIMSS includes explaining observable physical phenomena in terms of density differences as an explicit objective in Physics. NAEP only includes density in a content statement related to characteristic properties of matter, which is similar to a Chemistry topic in TIMSS.
Work and simple machines	TIMSS only	TIMSS includes basic knowledge of the concept of work and the function of simple machines (e.g., levers and ramps). This topic is not included in the NAEP framework.
Pressure (force/area) and its effects	TIMSS only	TIMSS includes the concept of pressure (force/area) and some effects due to pressure (e.g., gas pressure in balloons, fluid levels, atmospheric pressure as a function of altitude). Although NAEP includes change in atmospheric pressure as a function of altitude in Earth and Space Sciences, the concept of pressure is not explicitly included as a Physical Science topic in the NAEP framework.

[1] Subatomic particles is a topic included in the NAEP framework at grade 12.
[2] Mixtures are included in the NAEP framework at grade 4 but are not a focus at grade 8.
[3] The concept of exothermic and endothermic reactions is included in the NAEP framework at grade 12.
[4] The sun as a source of energy and light is included in TIMSS at grade 4.
[5] Basic knowledge of the properties of light is included in the NAEP framework at grade 4, but not at grade 8.
[6] A basic understanding of the characteristics of sounds is included in NAEP at grade 4.
[7] Basic knowledge of complete circuits and conductivity is included in the NAEP framework at grade 4.
[8] The knowledge of basic properties of permanent magnets and electromagnets is included in the NAEP framework at grade 4.
NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Physical Science content area can be found on pages 23–35 of the NAEP science framework. The Physics content domain can be found on pages 72–75 of the TIMSS science framework; the Chemistry content domain can be found on pages 69–71 of the TIMSS science framework.

Out of 11 topics in the Earth and Space Science content area, 5 were rated as similar across the two frameworks. Three topics were rated as being present in both frameworks, but in a way that was not similar. There were two topics covered only in NAEP, including "Earth's magnetic field." There was one topic, "Renewable and nonrenewable resources," that is present only in the grade 8 TIMSS framework. This concept is present in the NAEP framework; however, it is included at grade 4 instead of grade 8.

Exhibit 8. Content comparison of 2011 grade 8 NAEP and TIMSS science frameworks: Earth and Space Sciences

Topic	Framework	Summary statement
Structure of Earth	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the structure of Earth, including physical characteristics of its layers (crust, mantle, and core) and lithospheric plates. Relating geological events (e.g., earthquakes, volcanoes, mountain building) to plate movement is included in both frameworks. NAEP also includes knowledge of lithospheric plates constantly moving at a rate of centimeters per year due to movements in the mantle.
Formation and characteristics of soil	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include formation and characteristics of soil, but the specific content differs. NAEP has more focus on the specific components of soil (organic and inorganic), including layers with different chemical compositions. TIMSS also includes uses of rocks, minerals, and soils.
Earth's atmosphere	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the composition of Earth's atmosphere, including the relative abundance of its main components (nitrogen, oxygen) and presence of other trace gases (e.g., water vapor and carbon dioxide). Relating changes in atmospheric conditions (temperature, pressure, composition) to altitude is also included in both frameworks.
Earth's history and geological processes	NAEP and TIMSS: Not Similar	Both NAEP and TIMSS include concepts related to Earth's history and geological processes (e.g., erosion, volcanic activity, mountain building, rock formation), but there are differences in the focus in each framework. Both include different types of rock formations, but TIMSS focuses more on the rock cycle. TIMSS also includes the formation of fossils and fossil fuels. NAEP focuses on the measurement of geologic time through observations of rock sequences and fossil evidence for changes in environmental conditions.
Earth's water cycle and distribution	NAEP and TIMSS: Similar	Both NAEP and TIMSS include knowledge of Earth's water cycle and the distribution of water on Earth. This includes the sun as the primary source of energy for the water cycle and the circulation and renewal of fresh water on Earth. TIMSS also explicitly includes comparisons of the physical state, composition, and relative distribution of water on Earth. The NAEP framework describes specific details of the circulation of water through Earth's crust, oceans, and atmosphere.
Climate and weather	NAEP and TIMSS: Not Similar	Concepts related to climate and weather are included in both NAEP and TIMSS, but there are some differences in the focus and level of specificity. NAEP focuses on global weather patterns and the effect of large-scale systems (e.g., wind patterns and ocean currents) on local weather. NAEP also includes the effect of oceans' thermal properties on climate. TIMSS includes global and local factors affecting weather patterns. TIMSS also explicitly includes seasonal climates in different geographical regions and causes of long- and short-term climatic changes.
Renewable and nonrenewable resources	TIMSS only	TIMSS includes examples of renewable and nonrenewable resources, including the advantages and disadvantages of different energy sources.[1]

Exhibit 8. Content comparison of 2011 grade 8 NAEP and TIMSS science frameworks: Earth and Space Sciences—Continued

Impact of humans on Earth systems and resources	NAEP and TIMSS: Similar	Both NAEP and TIMSS include the impact of human activities on Earth systems and resources (land, water, and atmosphere). Both frameworks include possible causes and effects of local, regional, and global environmental concerns (e.g., pollution, global warming, deforestation) as well as the role of humans in addressing these concerns. The TIMSS framework describes specific methods of resource conservation and waste management (e.g., recycling), ways of obtaining fresh water (e.g., purification, desalination, and irrigation), and the importance of water conservation. The NAEP framework also includes the impact of humans on animal and plant populations as cross-cutting content with Life Science.
Earth in the solar system	NAEP and TIMSS: Similar	Both NAEP and TIMSS include a model of the solar system to explain phenomena on Earth (e.g., day/night, year, seasons, moon phases, eclipses, appearance of sun, moon, and planets) in terms of the relative distance, size, and motion of the Earth, sun, moon, planets, and other objects. Both frameworks include the role of gravity in keeping these objects in regular motion and relating the seasons to the tilt of Earth's axis of rotation. NAEP explicitly includes seasonal variations in the intensity of sunlight and length of day and knowledge of the sun as an average star. TIMSS also includes comparing and contrasting physical features of Earth with other bodies in the solar system (e.g., atmosphere, temperature, water, period of revolution and rotation, ability to support life) and describes objects outside the solar system (e.g., constellations).
Earth's magnetic field	NAEP only	The NAEP framework includes knowledge of Earth's magnetic field. This topic includes similarities to permanent magnets (north/south poles and lines of force) and the use of compasses for navigation. Although TIMSS includes properties of permanent magnets and effects of magnetic force in Physics, Earth's magnetic field is not included.
Sun as the primary energy source for Earth phenomena and the role of convection	NAEP only	NAEP includes the sun as the major source of energy for phenomena on Earth's surface. This includes the role of convection in producing winds, ocean currents, and the water cycle. While TIMSS includes the sun as the source of energy for the water cycle, the role of convection in other surface phenomena is not explicitly included in Earth Science.

[1] The concept of renewable and nonrenewable resources is included in the NAEP framework at grade 4, but is not a focus in the grade 8 framework.

NOTE: The rating is "similar" when at least 4 out of 6 panelists assigned a rating of 3 ("quite similar, but with some differences") or 4 ("exactly or almost the same"); otherwise, it is "not similar." Topics correspond to the final groupings of objectives/content statements by the expert panel. The title of each topic provides a brief description of the main concept(s) covered by the grouping. The Earth and Space Sciences content area can be found on pages 47–59 of the NAEP science framework. The Earth Science content domain can be found on pages 76–79 of the TIMSS science framework.

After comparing the content dimensions of the frameworks, the panel spent the remaining time comparing the cognitive dimensions and other features of the science frameworks. All six panel members worked as a group to generate the following list of statements to capture the major differences between the two frameworks:

- The NAEP science framework describes the cognitive dimension in terms of four science practices:[17] Identifying Science Principles, Using Science Principles, Using Scientific Inquiry, and Using Technological Design.
- The TIMSS science framework defines the cognitive dimension in terms of three cognitive domains: Knowing, Applying, and Reasoning.
- Even though the NAEP and TIMSS frameworks have different ways of organizing the cognitive dimension, they seem to require the same basic processes. However, the NAEP framework calls for hands-on performance tasks and interactive computer tasks in addition to paper-and-pencil items.[18] These tasks require students to conduct investigations, permitting a fuller measure of scientific inquiry skills than is possible with paper-and-pencil items. The computer tasks in NAEP also include information search and analysis and simulations involving phenomena that would not be feasible to assess using paper-and-pencil items.
- With some exceptions, it is possible to align the NAEP and TIMSS cognitive categories. In general, the skills and abilities in the Knowing cognitive domain in TIMSS align with the practice of Identifying Science Principles in NAEP. Similarly, the Applying cognitive domain in TIMSS aligns with Using Science Principles in NAEP, although there is overlap at the boundary between Knowing and Applying. The Reasoning cognitive domain in TIMSS includes NAEP performance expectations related to both Using Scientific Inquiry and Using Technological Design. Based on these alignments and the target percentages, the TIMSS framework has slightly more emphasis on Knowing (35 percent) and less on Reasoning (30 percent) than NAEP (25 and 40 percent, respectively).
- There are some notable differences in the two frameworks related to formulating hypotheses. TIMSS includes formulating hypotheses as testable assumptions in the Reasoning cognitive domain. While NAEP includes making predictions, designing investigations, and using evidence to validate conclusions, formulating hypotheses is not included in the description of performance expectations for Using

[17] The NAEP framework also describes four cognitive demands that underpin the science practices: declarative knowledge (knowing that), schematic knowledge (knowing why), procedural knowledge (knowing how), and strategic knowledge (knowing when and where to apply knowledge). There are no targets specified in the framework for the coverage of cognitive demands. Rather, these provide further elaboration on the skills and abilities to be measured by items across the science practices.

[18] Student performance on the hands-on-tasks and interactive computer tasks was reported separately from the main 2009 NAEP science assessment and was not part of the 2011 NAEP-TIMSS linking study.

Scientific Inquiry at grade 8. In addition, demonstrating knowledge of scientific instruments is in the Knowing cognitive domain in TIMSS, while using appropriate tools and techniques is included in Using Scientific Inquiry in NAEP.

- In TIMSS, inquiry skills are included in the Reasoning cognitive domain and are further elaborated in a separate section on Scientific Inquiry. Although there is a strong overlap between the expectations in NAEP and TIMSS with respect to the inquiry skills to be assessed, the TIMSS framework does not specify a target for the percentage of inquiry skills to be assessed.
- Although there is overlap between NAEP and TIMSS with respect to performance expectations related to Using Technological Design (e.g., considering alternative solutions and weighing advantages and disadvantages), the two frameworks do not have the same level of emphasis. In NAEP, Using Technological Design describes the systematic process of applying science to solve design problems. In TIMSS, skills and abilities related to problem solving are embedded in the Reasoning cognitive domain, and there are no specific targets for these component skills in the framework. Also, TIMSS includes the consideration of both scientific and social factors to evaluate the impact of science and technology. NAEP is restricted to the consideration of scientific constraints and trade-offs in design decisions.
- The NAEP framework places limits on the level of mathematics required (typically 1–2 years below grade level) since calculators are not used during the science assessment. NAEP prioritizes qualitative or semi-quantitative understanding rather than the formulaic use of equations. Quantitative problems involving mathematical relationships or formulas are restricted to those directly relevant to the content statements and only involve simple calculations. TIMSS includes using a science relationship, equation, or formula to find a qualitative or quantitative solution. Without evaluating the item pools, it is not possible to directly compare NAEP and TIMSS with respect to the level of quantitative reasoning, but the use of calculators does open up more possibilities for quantitative items in TIMSS.

Conclusion

Perhaps the two most important sources of information on the achievement of students in the United States are NAEP and U.S. participation in international assessments, including TIMSS. Although NAEP and TIMSS both are administered to students in grade 8, each assessment has a unique purpose and framework. This study sought to compare the mathematics and science frameworks for the 2011 administrations of NAEP and TIMSS at grade 8.

Two expert panels (one for mathematics and one for science) convened in October 2012 to compare the NAEP and TIMSS frameworks in terms of both content and other important dimensions (e.g., cognitive complexity). Panelists reacted to content comparison documents that had been prepared in advance by AIR staff, rated the similarity of the two frameworks using a 4-point scale, and generated statements about the ways in which various dimensions of the two frameworks were "similar" or "not similar."

The comparison of the NAEP and TIMSS mathematics frameworks found that, in general, there were many similarities. At the overall framework level, all six experts assigned a rating of 3 ("quite similar, but with some differences"). All of the NAEP and TIMSS mathematics content areas were judged by the expert panel to be similar, even though the organization of the mathematics content dimension differed (e.g., measurement is an explicit content area in NAEP but not in TIMSS). Seventy percent of the NAEP mathematics objectives were rated as similar to objectives in the TIMSS framework, and 85 percent of the TIMSS mathematics objectives were rated as similar to objectives in the NAEP framework.

The expert panel discussions of the NAEP and TIMSS mathematics frameworks focused on other ways in which the frameworks differed. The cognitive dimension within the two frameworks is defined differently. NAEP uses levels of complexity, a hierarchical scheme linked to an ordered description of the demands placed on student thinking independent of the difficulty of the mathematics content. TIMSS classifies items into three cognitive domains: Knowing, Applying, and Reasoning. While there is some correlation between the levels of complexity in the NAEP framework and the cognitive domains in the TIMSS framework, especially at the low and high levels of cognitive demand, the two dimensions are not interchangeable. An examination of the interaction between the content and the

cognitive dimensions within individual items from the two assessments is needed to further illustrate the similarities and differences between the two frameworks.

Mathematics content objectives in the NAEP framework are usually written to a greater level of specificity than are those in the TIMSS framework. The NAEP mathematics framework also includes detailed lists of measurement and geometry formulas, tools, and measurement conversions that students are expected to know; these are not specifically referred to in the TIMSS mathematics framework. Calculators can be used on approximately one-third of the NAEP mathematics assessment. While the use of calculators on the TIMSS mathematics assessment is left up to the individual country, all items are to be written so that access to a calculator does not advantage or disadvantage any students.

The comparisons of the NAEP and TIMSS science frameworks found that some aspects of the frameworks were similar, while others were not. At the overall framework level, four of the six experts assigned a rating of 3 (“quite similar, but with some differences”), while the remaining two experts assigned a rating of 2 (“quite dissimilar, but with some overlap”). Only one of the three content areas in the NAEP framework (Life Science) was rated as similar to the corresponding content area in the TIMSS framework (Biology). Overall, slightly more than half (56 percent) of the NAEP science content statements were rated as similar to objectives in the TIMSS science framework, while slightly less than half (44 percent) of the TIMSS science objectives were rated as similar to content statements in the NAEP science framework.

The expert panel discussions of the NAEP and TIMSS science frameworks focused on several aspects of the two frameworks. There are notable differences in the distribution of assessment time across content areas. The inclusion of separate subscales for Chemistry and Physics in TIMSS results in a larger number of Physical Science topics in TIMSS than in NAEP. With some exceptions, it is possible to align the cognitive categories of the NAEP and TIMSS science frameworks. Based on these alignments and the target percentages of the assessments devoted to each content area, the TIMSS framework has slightly more emphasis on Knowing and less on Reasoning than the NAEP framework.

Cross-cutting content is an explicit part of the NAEP science framework, with some related concepts included in multiple content areas. This results in some differences across the two

assessments in the specific topics included in the content area subscales. Some concepts or topics in the TIMSS science framework (particularly in Physics and Chemistry) are included at a different grade in the NAEP science framework, although the specific expectations would be different. The NAEP science framework includes hands-on performance tasks and interactive computer tasks in addition to the paper-and-pencil component. Calculators are allowed for the TIMSS science assessment, but not for the NAEP science assessment.

It is important to keep in mind that this study is a framework-to-framework comparison of the 2011 NAEP and TIMSS mathematics and science assessments. It focuses on the frameworks' content and cognitive dimensions and does not include item-level comparisons. Therefore, some caution is warranted in interpreting the results. Ideally, they should be considered in combination with the results from the companion item-level study, *A Comparison of the 2011 Trends in International Mathematics and Science Study (TIMSS) Assessment and the 2011 National Assessment of Educational Progress (NAEP) Mathematics and Science Assessments*.

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Appendix A

Table A-1. Description of the 2011 NAEP grade 8 mathematics framework

Content areas	Number of subtopics	Number of objectives	Target percent
Total	24	101	100
Number Properties and Operations	6	27	20
Geometry	5	21	20
Measurement	3	13	15
Data Analysis, Statistics, and Probability	5	22	15
Algebra	5	18	30
Mathematical complexity			
Total			100
Low complexity			25
Moderate complexity			50
High complexity			25

NOTE: The framework targets by content areas are for the percentage of assessment items. The framework targets by mathematical complexity are for the percentage of assessment time.
SOURCE: National Assessment Governing Board, *Mathematics Framework for the 2011 National Assessment of Educational Progress,* 2010.

Table A-2. Description of the 2011 TIMSS grade 8 mathematics framework

Content domains	Number of topics	Number of objectives	Target percent
Total	13	41	100
Number	4	12	30
Geometry	3	9	20
Data and Chance	3	8	20
Algebra	3	12	30
Cognitive domains			
Total			100
Knowing			35
Applying			40
Reasoning			25

NOTE: The framework targets by content domain and cognitive domain are for the percentage of assessment time.
SOURCE: International Association for the Evaluation of Educational Achievement, *TIMSS 2011 Assessment Frameworks,* 2009.

Table A-3. Description of the 2011 NAEP grade 8 science framework

Content areas	Number of subtopics	Number of content statements	Target percent
Total	18	43	100
Life Science	5	12	30
Physical Science	6	16	30
Earth and Space Sciences	7	15	40
Science practices			
Total			100
Identifying Science Principles			25
Using Science Principles			35
Using Science Inquiry			30
Using Technological Design			10

NOTE: The framework targets by content area and science practice are for the percentage of assessment time.
SOURCE: National Assessment Governing Board, *Science Framework for the 2011 National Assessment of Educational Progress*, 2010.

Table A-4. Description of the 2011 TIMSS grade 8 science framework

Content domains	Number of topics	Number of objectives	Target percent
Total	18	50	100
Biology	6	17	35
Chemistry	3	10	20
Physics	5	13	25
Earth Science	4	10	20
Cognitive domains			
Total			100
Knowing			35
Applying			35
Reasoning			30

NOTE: The framework targets by content domain and cognitive domain are for the percentage of assessment time.
SOURCE: International Association for the Evaluation of Educational Achievement, *TIMSS 2011 Assessment Frameworks,* 2009.

Appendix B

Exhibit B-1. Mathematics Expert Panelists

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