Technical Appendix A

Quantifying the Reading Demands of the TIMSS 2011 Fourth Grade Mathematics and Science Items

This document presents the coding guide that was used in order to quantify the readability information of TIMSS 2011 mathematics and science items in preparation for the reading demands analysis found in the Impact of Reading Ability on TIMSS Mathematics and Science Achievement at the Fourth Grade: An Analysis by Item Reading Demands (Mullis, Martin, & Foy, 2013). This information was used in order to consider reading achievement at the fourth grade in PIRLS 2011 in relation to the level of reading demands in the fourth grade TIMSS 2011 mathematics and science items. This document presents an overview of the methodology used in order to code items from the TIMSS 2011 mathematics and science assessments, followed by sample mathematics and science items and their coding.

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In order to quantify the readability information of the TIMSS fourth grade items, each individual item was coded for reading demands according to the following four dimensions:

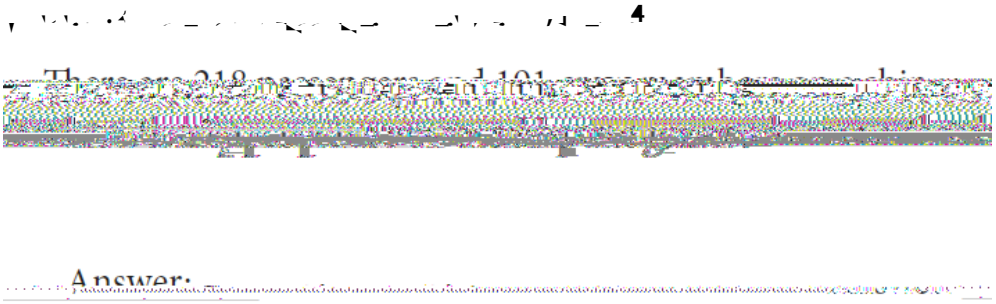
1. Length;
2. Subject-specific Vocabulary;
3. Symbolic Language; and
4. Visual Displays.

In order to facilitate the abovementioned analysis on the impact on reading ability on TIMSS 2011 mathematics and science achievement, staff at the TIMSS & PIRLS International Study Center at Boston College generated a coding guide. This guide is presented in the following pages and provides instruction for quantifying each of these dimensions with example TIMSS mathematics and science items.

[illegible][1]

Definition: The number of words in an item.

Indicator: Count the total number of words appearing anywhere in the item, including visual displays. Do not include numerals, labels (e.g., the "A" in "Angle A"), signs of operation, units (e.g., °C), variables, or abbreviations—these are considered symbolic language.[2] Exhibit A.2 presents an example TIMSS mathematics item.



Number of Words: 17

Note: The directive text ("Answer") in the response section should not be counted.

[1] See Chall & Dale (1995).

[2] Symbolic language is described in more detail in the Component 3 section of this guide.

Definition: Mathematical or scientific words or phrases that are subject-specific (e.g., symmetry, number sentence, fraction, melting, mixture). Exhibit A.3 presents an example TIMSS fourth grade mathematics items with subject-specific vocabulary.

When coding this component, please remember that words can have multiple meanings. If the meaning used in the item is highly subject-specific (e.g., face or edge in a geometric shape), this should be counted as subject-specific vocabulary. However, if the word is not used in a mathematical or scientific sense, it should not be counted. For example, in the phrase "circle the number," the word "circle" should not be counted as being subject specific.

Indicators:

Count the number of unique subject-specific words or phrases; and
Count the number of times each subject-specific word or phrase is used.

Number of Subject-Specific Terms: scale–1; centimeter–2; kilometers–2

Note: **D** . However, this sometimes means that terms that fall into the same category are counted differently. In order to help guide the coding process, we have provided some examples of this below (see Exhibit A.4). Please note that this list is not exhaustive.

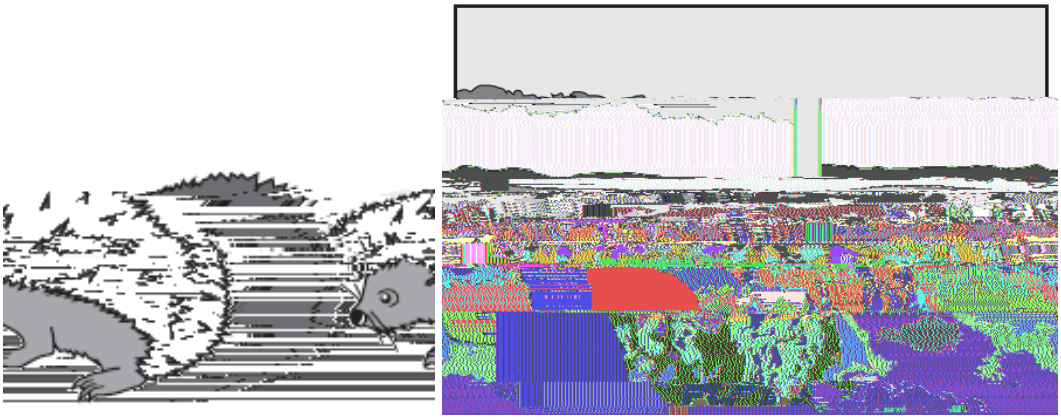
Ca egor.	E amples Of Technical Vocab lar.	E amples Of Vocab lar. No Considered As Technical
Ma hema ics		
Units of Measurement	Kilometers, Zeds, Hours, Minutes	Days, Months
Numbers in Word Form	Three-digit numbers or higher (e.g., three thousand and thirty three is one technical phrase)	One or two-digit numbers (e.g., four)
Mathematical Operators	Add, Multiply, Equal	
Geometric Elements	Square, Circle, Cube, Point, Line, Edge, Face	Side
General Measurement Terms		Weigh/weight, Long/length, Wide/width
Visual Displays		Diagram, Graph, Table, Figure, Map
Other Mathematical Terms	Digit, Estimate	Number, Pattern, Shape, Data
Science		
Science Instruments	Thermometer, Beaker	
Materials	Copper, Iron, Calcium, Rust, Soil	Metal, Wood, Battery
Biological /Anatomical Terms	Organs, Skull, Stomach, Female, Foot Structure	Arms, Legs, Teeth, Girl
Animal Features	Flippers, Whiskers, Scales	Fur, Hair, Skin
Animal Habitats	Rainforest, Grassland	Ocean, Desert
Plant and Animal Groups	Flowering plant, Mammal, Reptile, Living Things	Birds, Fish, Insects
Specific Animals and Plants		Whale, Dog, Cactus, Grass
Plant Parts	Stalk	Leaves, Flowers, Roots, Stem
Common Earth features	Plains, Fresh Water	Mountain, River
Astronomic Elements	Solar System, Planets, Orbit	Earth, Sun, Moon, Stars
Developmental Stages of Animals (used in context of life cycles)	Pupa, Tadpole	Kitten
Other Science Terms	Temperature, Electricity, Energy, Environment	Survive, Function

Definition: Numerals, labels (e.g., the “A” in “Angle A”), signs of operation (e.g., +, =), units (e.g., °C), variables (e.g., x), and abbreviations (e.g., cm). Exhibit A.5 [illegible]

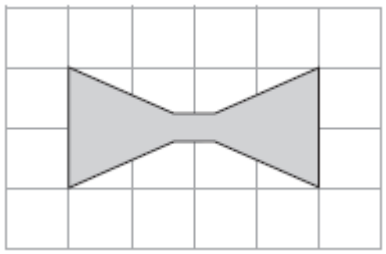
There are three steps to evaluating visual displays in the TIMSS mathematics and science fourth grade achievement items:

1. Identify the type of representation;
2. Quantify the density of the visual display; and

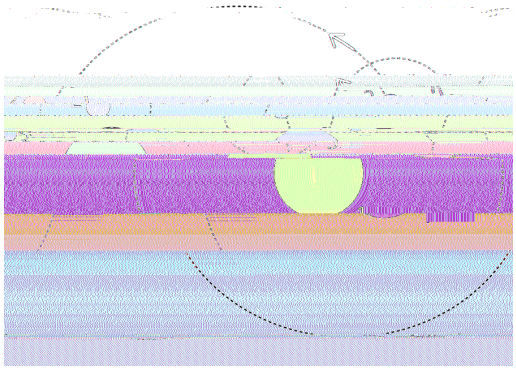
1. **P R** : Images of real world objects (e.g., animals, bicycles, number card) not in a system or experimental set-up, or geometric shapes that are not being presented for their geometric properties (e.g., circles replicated to demonstrate a pattern). Exhibit A.6 presents sample pictorial representations from fourth grade TIMSS science items.

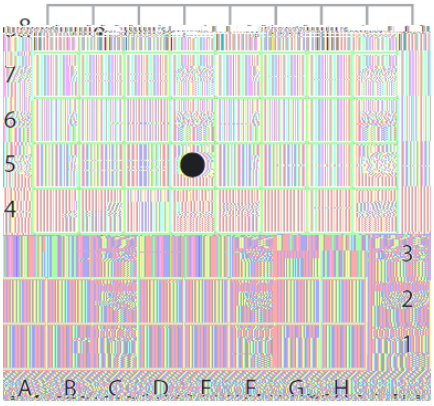


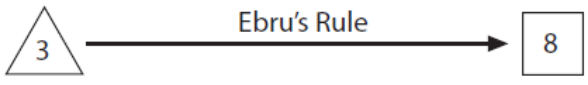
2. **G** : Points, lines, angles, two-dimensional shapes (e.g., square, triangle, circle) or three-dimensional objects (e.g., cube, pyramid, sphere) being presented for their geometric properties (e.g., volume, angles, area). A geometric element on a grid should be coded as a geometric shape. Exhibit A.7 presents examples of geometric shapes from two fourth grade TIMSS mathematics items.



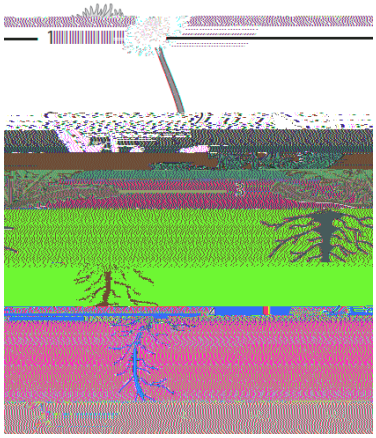
3. **M** : Simplified representations of systems (e.g., informal coordinate system with axes for mathematics, solar system diagram for science); diagrams of processes (e.g., plant growth); visual representations of functions; or instruments representing an experimental set-up. An experimental set-up must include manipulation of the conditions. Exhibit A.8 presents examples of models from fourth grade TIMSS mathematics and science items.







4. [redacted][6]: Structures with at least 2 adjoining rows and 2 adjoining columns with grid lines.
   Exhibit A.8 presents a table from a TIMSS fourth grade science item.
   Note: Pictographs in table form should be coded as graphs (see below).

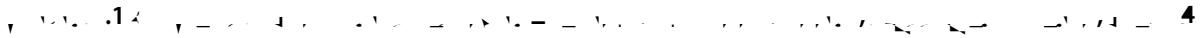


Density: 4 (flower, stem, leaves, roots; note that the labels 1–4 are not counted separately).

2. **G**: Count each major geometric shape (e.g., point, line, square, or cube) and its label (if applicable) as one element. Exhibit A.12 presents examples of geometric shapes of varying density from TIMSS fourth grade mathematics items.

   Notes:

   If a geometric shape is shown on a grid, both the shape and the grid should be counted as separate elements.
   For 2-dimensional compound shapes, count each shape as a separate element (see second example below). However, for 3-dimensional objects (e.g., pyramid), count each object as one element (see third example below).
   If a line has labeled endpoints, the endpoints should not be counted as elements separate from the line.
   Count all right angle indicators as one element.
   Count all equal length or equal angle indicators as one element.
   Count scales, measurements, or axes as one element each.



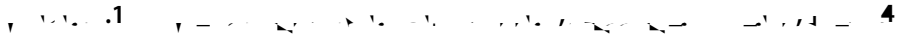
Density: 4 (geometric shape; grid; 2 measurements)

Density: 16 (13 visible cubes, 3 axes)

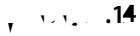
Density: 4 (4 triangles)

Density: 1 (cube)

3. **M** – Count each major component; that is, 1) a whole object, or 2) major part of an object that is labeled. A label is counted with its object, not separately. If there are grids or axes in the model, these should each be counted as separate elements. Exhibit A.13 and A.14 present examples of models of varying density from TIMSS fourth grade items.

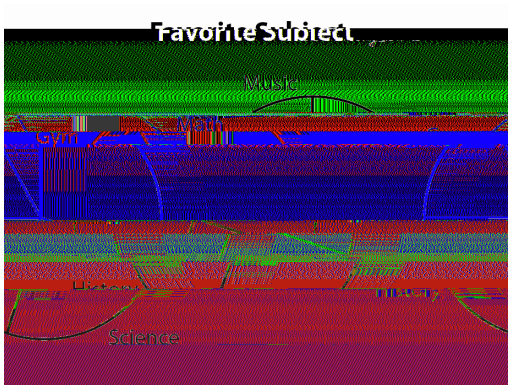


Density: 12 (4 labeled streets; 5 labeled locations; 2 axes; 1 grid)



For pie charts, count:

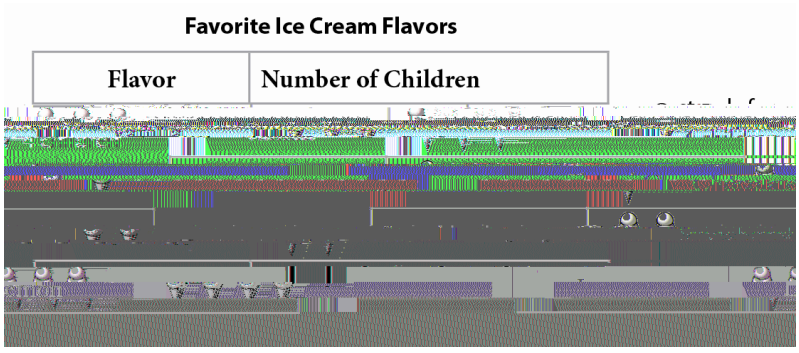
Each labeled category as one element (do not count label separately; even if the legend is displayed on one side, count the labels with their respective categories);
The individual pie wedges indicated by the dotted lines are not counted as separate elements if they are not each a labeled category; and
Title of the chart as one element.



Density: 6 (5 labeled categories, 1 title).

For pictographs, count:

Each group (e.g., row) of pictures and their label as one element;
Key as one element; and
Title of the graph as one element.



Density: 6 (4 groups of pictures, 1 key, 1 title).

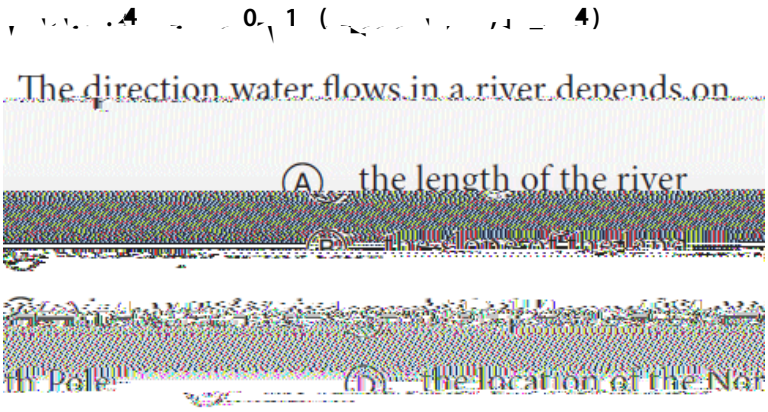
Length: 74 words
Subject-specific Vocabulary: balance–2; cubes–11
Symbolic Language: 1 (7 instances); 2 (3 instances); 3 (7 instances); 4 (6 instances)
Visual Displays:

- Type of Visual Display: Model
- Density: 3 (1 balance; 2 cubes)
- Interaction: Necessary

Exhibits A.23 through A.27 present items that illustrate some of the finer points of the reading demands coding guide, discussed above, and that raised some discussion during the coding process. To aid researchers in understanding the application of the reading demands coding guide to these items, rationales explaining the coding decisions have been provided.

Length: 10 words
Subject-specific Vocabulary: 0
Symbolic Language: A (2 instances); B (2 instances); C (2 instances)
Visual Displays:
Type of Visual Display: Pictorial Representation
Density: 4 (bus; window; wheel; sign)
Interaction: Necessary

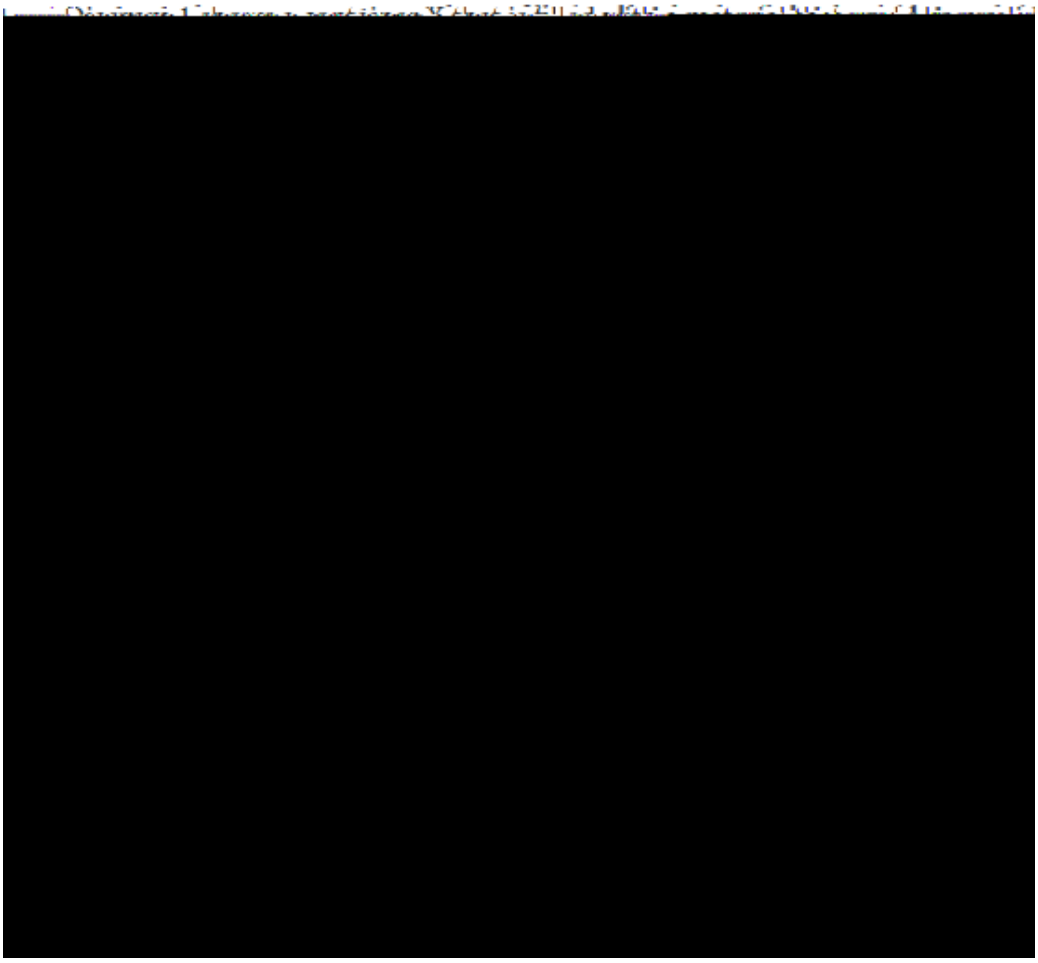
This visual display is considered a pictorial representation,l representatio7 Tf12ei1B Td(j0 d) oN j(,liis visualge,li



Length: 34 words

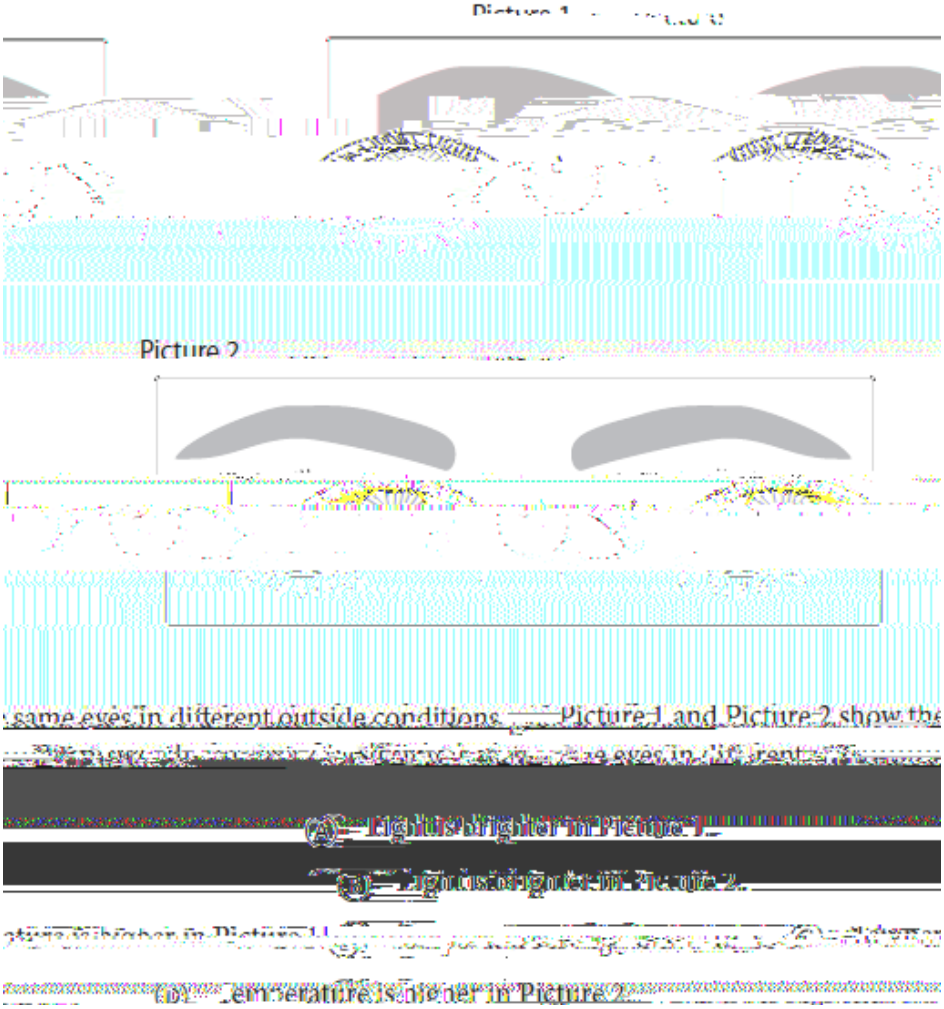
Subject-specific Vocabulary: 0
Symbolic Language: 0
Visual Displays: None

The term “slope” in this item is not considered subject-specific vocabulary because it is not being used in a mathematical sense. In the context of this science item, the term is being used as an everyday way of referring to the natural incline of the ground.



Length: 81 Words
Subject-specific Vocabulary: Solid (1 instance); Liquid (1 instance); Gas (2 instances)
Symbolic Language: X (4 instances); Y (2 instance); 1 92 instances); 2 (2 instances);
3 (1 instance); 4 (1 instance); 5 (instance)
Visual Displays:
Type: Model
Density: 11
Interaction: Necessary

This visual display is considered one model because it depicts the various stages of one experiment. Diagrams 1 and 2 are the experimental steps and Diagrams 3–5 are the possible outcomes.



Length: 43
Subject-specific Vocabulary: 0
Symbolic Language: 1 (5 instances); 2 (5 instances)
Visual Displays:
- Type: Model
- Density: 4 (2 pairs of eyes, 2 pairs of eyebrows)
- Interaction: Necessary

This visual display is considered a model because it shows the change in the eyes when the light conditions are altered. There are four elements of density because each pair of eyes is counted as an object, as are each pair of eyebrows. Please note that the labels are not counted separately from the eyes that they are labeling, and that the noses are not counted because the entire nose is not shown.

Berardo, A.B.I. (2005). Language and modeling word problems in mathematics among bilinguals. *13* (5), 413-425.

Chall, J.S. & Dale, E. (1995). . Cambridge, MA: Brookline Books.

Hunt, K.W. (1970). Syntactic maturity in school children and adults. *3* (1, Serial No. 134).

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