# SHADOWS

The Shadows task measures both science and mathematics concepts and skills and is one of the two "combination" tasks. Students were asked to move an object (a square card on a stand) placed between a light source and a screen to investigate how the positions of the light source, the card, and the screen are related to the size of the shadow cast upon the screen. At the eighth grade, Items 1 and 2 (Figure 1.10) were intended to assess students' ability to follow directions, report on their observations, and use their conceptual knowledge of light and shadow to explain why the shadow was always larger than the card. Item 3 asked students to find and record at least three positions of the light and the card that would make the shadow twice the size of the card. Students then were asked to conduct an investigation to find a general rule for varying the distance between the light and the card and the card and the screen so that the shadow is always twice the size of the card. In Item 4, students were asked to describe their investigation. They were required to present their measurements in tabular form (Item 5) and then to derive the general rule (Item 6).

To do well on this task, it was important to understand how shadows are formed and that light travels in straight lines. In addition, the ability to recognize similar triangles and apply some of their properties could be very helpful in deriving a mathematical rule. However, it was also possible to arrive at a generalization empirically, without considering (or at least without explicitly referring to) similar triangles formed by the light rays, the card, and the screen.

The fourth-grade version of the Shadows task (Figure 1.11) provided simpler, more explicit directions and a table for recording the data, and placed the explanation item much later in the task, after students had more experience with the phenomenon. For fourth-grade students, except for the last two items, Shadows was largely a procedural task based on following directions. Thus, no performance comparisons are possible between the two grades, even for items that appear identical.

Except for the initial observation item (Table 1.11, Item 1 – average percentage score: 75%), this task proved difficult for most eighth-grade students. In conducting the investigations, students in some countries either assumed that they need not present new measurements or failed to list data in organized tabular form. Many estimated distances "by eye" rather than by measuring. Most students achieving full credit on deducing a general rule (Item 6 – average percentage score: 21%) based their answers on empirical data rather than a geometric approach. However, in a few instances careful investigations were carried out, with measurements so precisely done that students could actually deduce the mathematical "rule" from their empirical data. About 2% of students internationally were successful at using a mathematical approach based on recognition of similar triangles to "find a rule when the shadow will always be twice the size of the card."

Even though it was structured differently, the fourth-grade students also had a lot of difficulty with this task (Table 1.12). The first four items were procedural and were guided by explicit directions. To begin, students had only to observe and describe in general what happened when they moved the light nearer to and further from the card (Items 1 and 2), which they managed quite well. Then students were asked to measure the width of the shadow and the distance from light to card (Items 3 and 4), which they found much more problematic. In the last three items, students were asked to find and record three positions where the shadow was twice as wide as the card, explain why the shadow is always larger than the card, and find a rule that tells when the shadow will always be twice as wide as the card. These tasks were clearly beyond the grasp of the fourth-grade students.

# FIGURE 1.10 - SHADOWS FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH GRADE



## ITEMS 1 AND 2

### SHADOWS

**At this station you should have:**

Flashlight (or torch) on a stand (this will be called "the light")
5 cm sq. card on a stand
Screen on which to form a shadow of the card
Meter ruler
30 cm ruler

**Read ALL directions carefully.**

*When the card is between the light and the screen, the card makes a shadow on the screen.*

**Your task:**

Find out how the size of the shadow changes as you move the card.

**This is what you should do:**

- Keep the card still and move the light closer to the card and further away.

1. What happens to the size of the shadow?

When you move the light closer to the card the shadow gets bigger and when you move the light away the shadow gets smaller.

2. Why is the shadow always larger than the card? You may draw a picture or diagram as part of your answer.

The shadow is always larger than the card because as the lights rays travel they get wider. When they hit the card they are narrower than when they hit the wall. The shadow is the light which gets blocked out by the card.

This means the light get reflected off the card on an outward angle which makes the shadow bigger



## ITEMS 3 AND 4

3. Now find at least three positions where you can put the light and the card to make a shadow twice as wide as the card. Record the distance from the card to the screen and from the light to the card for these three positions.

1) 13.5 cm from card to screen 13.5 cm from card to light
2) 15 cm from card to screen 15.5 cm from card to light
3) 10 cm from card to screen 9.5 cm from card to light

You are now going to do an investigation to try to find a general rule for how far away from the screen the card and the light should be placed to make the shadow twice as wide as the card.

**You will need to:**

- decide what to measure
- decide how to present your measurements clearly and simply
- draw what conclusions you can from your measurements

4. Describe what you did in your investigation. A picture may be useful.

For my investigation I put a ruler at the back of a box I then moved the light around until the shadow was twice as big as the card. I then measured the distances from the card to screen and from the card to the light. I repeated this 3 time using the lights in different positions.

**Please turn the page.**

## ITEMS 5 AND 6

5. Present your measurements in as clear a way as possible.

| Position number | distance from screen to card | distance from card to light (cm) |
|---|---|---|
| 1 | 13.5 cm | 13.5 cm |
| 2 | 15 cm | 15.5 cm |
| 3 | 10 cm | 9.5 cm |

6. What general conclusion can you draw from these results? Try to write a rule that describes when the shadow will always be twice as wide as the card.

From these results I draw the conclusion that the card must be as far away (approximately) from the screen as it from the light.

Rule - To find a shadow twice the size of a card place the card half way between the screen and the light.

**PUT THE MATERIALS BACK THE WAY YOU FOUND THEM SO THAT SOMEONE ELSE CAN USE THIS STATION**

page 3 TASK SM1-P2

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Describe how shadow size changes in response to distance of light.** i) Comments appropriately on the size of shadow. ii) Comments on the relationship between the distance from light and size of shadow. *Total Possible Points: 2*

**Item 2 - Explain why shadow is larger than card.** i) Includes concept of light traveling in a straight line and spreading out from a source. ii) Explanation or diagram shows how the shadow is formed. *Total Possible Points: 2*

**Item 3 - Record distances for three positions where shadow is twice as large as card.** i) Records at least 3 measurements where shadow is twice the size of card. ii) Measurements are paired: distance from light to card and distance from card to screen. iii) Measurements are plausible: the distance from card to screen and distance from light to card are equal (within ±10%). *Total Possible Points: 2*

**Item 4 - Describe investigation.** i) Includes description of how measurements were taken. ii) Includes taking measurements of both distances and shadow width. *Total Possible Points: 2*

**Item 5 - Present measurements.** i) Measurements presented in a list, table or by graph. ii) Measurements are clearly and completely understandable with appropriate units, labels, and descriptors. *Total Possible Points: 2*

**Item 6 - Write a general rule to describe when shadow will always be twice as wide as card.** i) Summarizes data in sentences, formula, or diagram. ii) Indicates that shadow will be twice as wide as card when the distance from light to screen is twice the distance from light to card. *Total Possible Points: 2*

# FIGURE 1.11 - SHADOWS ITEMS AND SCORING CRITERIA – FOURTH GRADE



## SHADOWS

**At this station you should have:**

Flashlight (or torch) on a stand (this will be called "the light.")
A 5 cm sq. card on a stand
Screen on which to form a shadow of the card
Meter ruler
30 cm ruler

**Read ALL directions carefully.**

*When the card is between the light and the screen, the card makes a shadow on the screen.*

**Your task:**

Find out how the size of the shadow changes as you move the card and the light.

**This is what you should do:**

- Keep the card in one place and move the light closer to the card.

1. What happens to the size of the shadow when you move the light closer to the card?

- Keep the card in one place and move the light further away from the card.

2. What happens to the size of the shadow when you move the light further from the card?

3. Put the card 5 cm from the screen. Put the light 10 cm behind the card. How wide is the shadow?

4. Put the card 10 cm from the screen and move the light until the shadow is twice as wide as the card. Measure the distance from the light to the card. Write your measurement in the table below.

5. Find three more places to put the light and the card where the shadow is twice as wide as the card. For each place, make the same measurements as you made before and write them in the table. Be sure to include the units for each measurement.

| Distance from card to screen | Distance from light to card |
|---|---|
| 10 cm | |
| | |
| | |
| | |

6. Why is the shadow always larger than the card? You may draw a picture as part of your answer.

7. Find a rule that tells when the shadow will ALWAYS be twice as wide as the card.

Task layout condensed for display

# FIGURE 1.11 (CONT.) SHADOWS – FOURTH GRADE

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Describe how shadow size changes when card is moved closer to light.** i) States that shadow becomes larger as card is brought closer to light.
*Total Possible Points: 1*

**Item 2 - Describe how shadow size changes when card is moved further from light.** i) States that shadow becomes smaller as card is pulled further from light.
*Total Possible Points: 1*

**Item 3 - Measure width of shadow when card and light are placed at specific distances.** Determines width by *measurement*. Measurement is accurate (7.5 cm ± 8 mm) for card 5 cm from screen and light 10 cm from card.
*Total Possible Points: 1*

**Item 4 - Measure distance from light to card where shadow is twice the size of card.** i) Distance from light to card is equal to the distance from card to screen (or half the distance from light to screen). ii) With card 10 cm from screen, correct measurement is10 cm ± 5 mm.
*Total Possible Points: 2*

**Item 5 - Record distances for three more positions where shadow is twice as large as card.** i) Table is complete. ii) Measurements are plausible: the distance from light to card is equal to distance from card to screen, within ± 10%.
*Total Possible Points: 2*

**Item 6 - Explain why shadow is always larger than card.**
i) Includes concept of light traveling in a straight line and spreading out from a source. ii) Explanation or diagram shows how shadow is formed.
*Total Possible Points: 2*

**Item 7 - Find a rule to predict when shadow will be twice as wide as card.** i) States that shadow will always be twice as wide as card when the distance from light to screen is twice the distance from light to card.
*Total Possible Points: 2*

# Table 1.11 Shadows Task: Average Percentage Score on Items – Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | |
|---|---|---|---|---|---|---|---|
| | | Item 1 Describe Observation | Item 2 Explain Observation | Item 3 Problem Solve and Record Distances | Item 4 Describe Investigation | Item 5 Present Measurements | Item 6 Conclude and Generalize |
| | | 2 Points | 2 Points | 2 Points | 2 Points | 2 Points | 2 Points |
| Singapore | 50 (3.5) | 90 (1.8) | 55 (6.0) | 41 (4.8) | 39 (3.5) | 46 (6.0) | 29 (4.6) |
| Sweden | 45 (1.9) | 82 (2.4) | 43 (3.9) | 57 (3.9) | 30 (3.3) | 27 (4.0) | 32 (3.5) |
| Iran, Islamic Rep. | 43 (1.5) | 84 (2.8) | 57 (3.9) | 33 (4.1) | 23 (2.4) | 24 (2.6) | 37 (2.8) |
| †1 Switzerland | 41 (2.1) | 80 (3.5) | 44 (4.9) | 43 (3.6) | 29 (3.7) | 22 (3.2) | 32 (3.3) |
| Norway | 39 (2.0) | 75 (3.0) | 28 (3.1) | 51 (3.4) | 25 (2.5) | 18 (3.1) | 35 (4.3) |
| Czech Republic | 37 (1.9) | 87 (2.7) | 48 (2.9) | 32 (3.5) | 27 (2.9) | 8 (2.4) | 19 (3.8) |
| † Scotland | 36 (2.4) | 83 (3.3) | 24 (3.3) | 31 (4.0) | 28 (4.3) | 36 (3.5) | 16 (3.4) |
| Spain | 36 (1.7) | 78 (2.9) | 40 (3.8) | 29 (2.7) | 37 (3.7) | 16 (3.0) | 16 (2.1) |
| Canada | 35 (1.6) | 75 (2.6) | 21 (3.2) | 34 (2.8) | 30 (2.3) | 28 (3.8) | 19 (2.5) |
| New Zealand | 29 (2.0) | 70 (3.5) | 17 (2.1) | 15 (1.7) | 21 (2.7) | 35 (2.8) | 13 (2.5) |
| Portugal | 25 (1.5) | 65 (3.2) | 27 (3.7) | 24 (2.7) | 16 (2.6) | 11 (2.3) | 7 (2.1) |
| Cyprus | 18 (1.5) | 64 (4.8) | 14 (3.2) | 8 (2.2) | 12 (2.7) | 3 (1.4) | 9 (2.3) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | |
| Australia | 36 (1.9) | 67 (3.7) | 24 (3.4) | 39 (3.8) | 32 (4.1) | 28 (4.4) | 25 (4.6) |
| 2 England | 46 (2.3) | 77 (2.9) | 33 (3.9) | 23 (3.3) | 47 (3.2) | 71 (3.7) | 23 (3.0) |
| Netherlands | 35 (2.8) | 55 (4.1) | 50 (5.2) | 33 (3.7) | 27 (3.3) | 25 (4.3) | 23 (3.9) |
| United States | 28 (1.9) | 64 (4.0) | 20 (2.4) | 13 (2.6) | 27 (2.8) | 34 (3.2) | 11 (2.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | |
| Colombia | 22 (2.5) | 54 (5.4) | 22 (2.7) | 21 (4.1) | 17 (3.5) | 14 (4.9) | 5 (1.9) |
| 3 Romania | 36 (2.8) | 92 (2.3) | 28 (3.6) | 24 (4.8) | 26 (4.8) | 17 (3.1) | 26 (5.1) |
| Slovenia | 31 (1.8) | 76 (3.3) | 29 (3.0) | 24 (2.7) | 24 (2.9) | 12 (2.1) | 19 (3.6) |
| **International Average** | 35 (0.5) | 75 (0.8) | 33 (0.8) | 30 (0.8) | 27 (0.8) | 25 (0.8) | 21 (0.8) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.
2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).
3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Shadows Task: Average Percentage Score on Items – Fourth Grade* Table 1.12

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Item 1 Describe Shadow: Closer | Item 2 Describe Shadow: Further | Item 3 Measure Shadow Width | Item 4 Measure Distance | Item 5 Record 3 More Measurements | Item 6 Explain Shadow Size | Item 7 Find General Rule |
| | | 1 Point | 1 Point | 1 Point | 2 Points | 2 Points | 2 Points | 2 Points |
| Canada | 36 (1.7) | 72 (3.0) | 70 (3.1) | 36 (2.9) | 22 (2.4) | 29 (2.3) | 12 (1.8) | 8 (1.2) |
| †1 New Zealand | 34 (1.0) | 86 (2.7) | 82 (2.9) | 32 (3.3) | 16 (2.7) | 14 (2.4) | 5 (1.4) | 3 (1.0) |
| Portugal | 27 (1.6) | 66 (4.8) | 63 (4.9) | 25 (4.1) | 16 (3.3) | 12 (1.8) | 4 (1.3) | 0 (0.0) |
| Iran, Islamic Rep. | 26 (2.1) | 61 (5.9) | 63 (5.8) | 13 (3.0) | 18 (4.2) | 15 (2.7) | 7 (2.4) | 3 (1.2) |
| Cyprus | 16 (1.6) | 47 (4.7) | 39 (4.7) | 11 (2.8) | 7 (2.1) | 5 (1.8) | 3 (1.8) | 1 (0.4) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | | |
| Australia | 33 (1.6) | 71 (4.5) | 72 (2.3) | 31 (6.0) | 20 (2.8) | 27 (2.7) | 4 (1.3) | 6 (1.9) |
| Hong Kong | 30 (1.6) | 65 (5.0) | 62 (3.3) | 24 (4.3) | 17 (3.1) | 17 (3.1) | 17 (5.0) | 5 (2.0) |
| United States | 33 (1.2) | 79 (2.6) | 81 (2.9) | 33 (3.7) | 19 (2.7) | 8 (1.5) | 7 (1.6) | 3 (1.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | | |
| Slovenia | 32 (1.8) | 77 (4.8) | 73 (4.9) | 32 (3.5) | 23 (4.0) | 12 (2.5) | 4 (1.1) | 6 (2.1) |
| **International Average** | 30 (0.5) | 69 (1.4) | 67 (1.3) | 26 (1.3) | 18 (1.0) | 15 (0.8) | 7 (0.8) | 4 (0.5) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.

● Percent of total possible points on each item averaged over students.

▼ Average of percentage scores across items; all items weighted equally.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)

1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# PLASTICINE

The Plasticine task also combines mathematics and science concepts and skills and is thus a "combination" task. Students were provided with a simple equal-arm balance and a supply of plasticine (modeling clay) and asked to use the balance to make lumps of plasticine of different weights. Eighth-grade students were given 20g and 50g weights and asked to form four lumps of plasticine: 20g, 10g, 15g, and 35g in weight (in that order), and to explain their strategy for forming each one. This task was intended to measure student understanding of the principle of the balance and the ability to use it, as well as mathematical problem solving in non-routine situations. Although the first item is a simple matter of building up a lump of plasticine that balances the 20g weight, the other three lumps can be made only by combining and dividing lumps in various combinations. These three problems require carefully thought-out problem-solving strategies but are essentially the same task, although of increasing complexity. Figure 1.13 presents the task, with a sample response and scoring criteria for a fully-correct response. All lumps of plasticine were handed in at the end of the session and the weights verified by the administrator.

The task for fourth-grade students was basically the same, except that the fourth graders were given only one 20g weight with the balance, and the required lumps were 20g, 10g, 30g, 15g. Items 1A, 1B and 2A, 2B are the same for both grade levels, and Items 4A, 4B for fourth-grade students correspond to Items 3A, 3B for eighth-grade students. Figure 1.14 shows the task for fourth graders.

In order to keep administration costs to a minimum, countries were encouraged to use balances constructed from everyday materials according to a design provided by the TIMSS International Study Center. Although these balances worked quite well, students at both grade levels had difficulty achieving accurate results. To compensate for this lack of precision, the scoring rubrics allowed a tolerance of ±10% for the two larger lumps and ±20% for the two smaller ones. However, some 30% of the eighth-grade students did not achieve this level of accuracy.

Eighth-grade students had no difficulty with the straightforward task of making a 20g lump (Table 1.13, Item 1A – average percentage score: 93%), or in describing how they accomplished this (Item 1B – average percentage score: 86%). The most difficult to make proved to be the 15g lump (Item 3B – average percentage score: 37%). The most popular strategy was to make a 20g lump; halve it, using the balance to obtain a 10g lump; and halve that to obtain a 5g lump that was then added to the 10g lump. The most popular strategy for Item 4B (making a 35g lump), was to use the weights and previously made lumps to build up a new lump of 35g: e.g., "I put the 50g weight on one side and my 15g lump on the other and added to the 15g side until they balanced."

Some of the eighth-grade students showed a lack of comprehension of how an equal-arm balance operates, and either attempted to use the slope of the balance arm to estimate weights, or (where commercially produced balances were used) used the small mechanism intended for balancing the instrument before use (zeroing) and tried to calibrate it (mentally) to determine weight: e.g., "I put the 20g weight in the scale and added plasticine till it reached this mark." Here the student has drawn the zeroing bar, arbitrarily named the zero point in the center as 20g, and "estimated" a marker about 4 divisions to the left to be 35g. The verified weight was 24 grams.

Fourth-grade students also found the task of making a 20g lump fairly easy (Table 1.14, Item 1A – average percentage score: 80%), but describing how they did it was more challenging (Item 1B – average percentage score: 52%). The other tasks, all of which involved the use of the balance to divide and sometimes combine previously made lumps, were very difficult for these students.

# FIGURE 1.12 - PLASTICINE FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH GRADE

## ITEM 1

### PLASTICINE

**At this station you should have:**

Some plasticine
A balance
Plastic bags
A 20 g and a 50 g mass (weight)
Colored small circular sticky labels

**Read ALL directions carefully.**

**Your task:**

Use the balance to weigh different amounts of plasticine as carefully as you can. Then explain how you made them.

**Before starting the task:**

MAKE SURE THE PANS ARE BALANCED WHEN EMPTY.

IF THEY ARE NOT, PUT YOUR HAND UP AND TELL THE TEACHER.

1a. Use the balance to make a lump of plasticine that weighs 20 g.

- When you have made the 20 g lump, write 20 g on a colored label and stick it on the lump. Put the lump in a plastic bag.

1b. Write down how you made the 20 g lump. I put the 20g weight in one of the tregs on the balance. I then started putting small amounts of plastic on the other trey. gradually the balance evenened out until it was the same on both sides. I knew the plasticine weighed 20g.

page 1 TASK SM2-P2

## ITEMS 2 AND 3

2a. Use the balance to make a lump of plasticine that weighs 10 g.

- When you have made the 10 g lump, write 10 g on a colored label and stick it on the lump. Put the lump in the plastic bag with the 20 g lump.

2b. Write down how you made the 10 g lump.

I made another 20g lump using the same method as before. Then I broke it in half and placed one on each trey on the balance. If one was heavier than the other I would break some of it off and put it on the lighter one. Eventually both lumps weighed the same and I knew each one would weigh 10grams.

3a. Use the balance to make a lump of plasticine that weighs 15 g.

- When you have made the 15 g lump, write 15 g on a colored label and stick it on the lump. Place the 15 g lump in the plastic bag together with the other lumps.

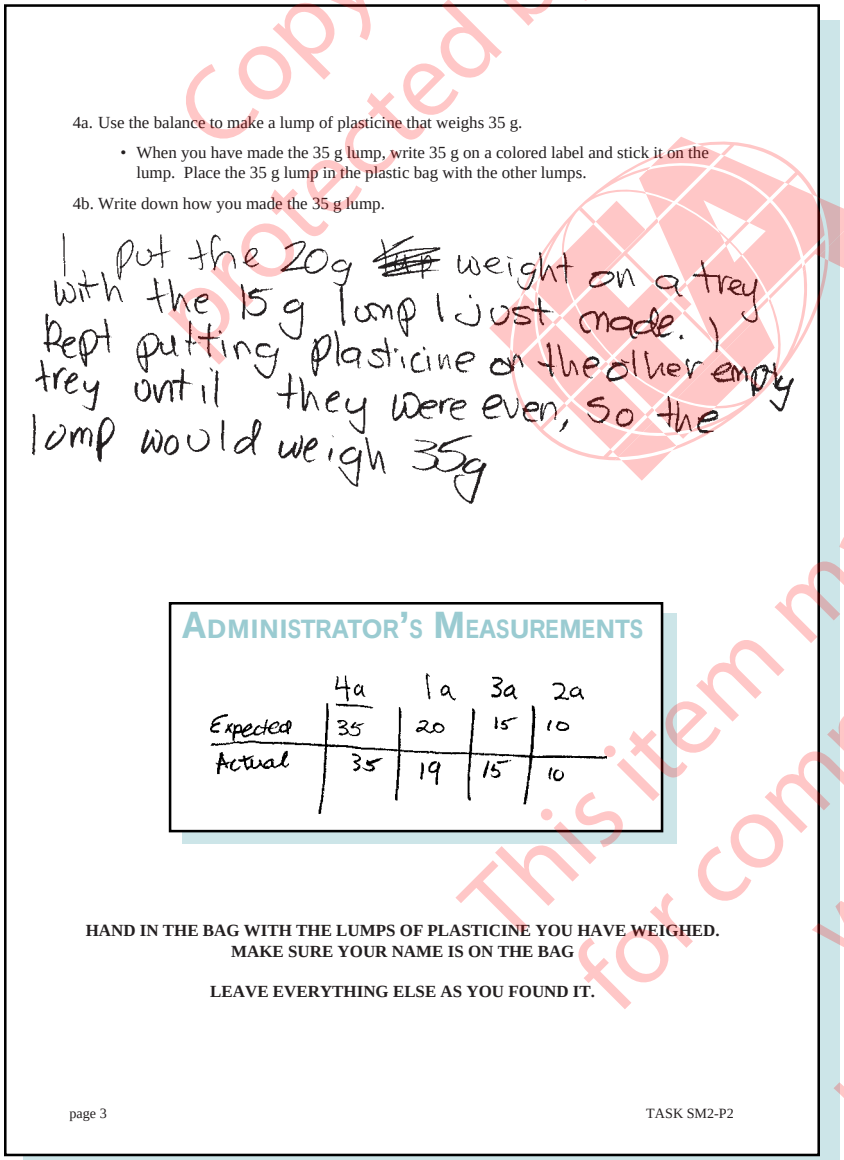
3b. Write down how you made the 15 g lump.

I used the 20g weight and the 10g lump, and I placed each one on a trey. I then made a lump that weighed the same. I then split it in half, I took the weights off the trey and using the same method as above, I made them even, so each would weigh 15grams

**Please turn the page.**

page 2 TASK SM2-P2

## ITEM 4 AND ADMINISTRATOR'S MEASUREMENTS



4a. Use the balance to make a lump of plasticine that weighs 35 g.

- When you have made the 35 g lump, write 35 g on a colored label and stick it on the lump. Place the 35 g lump in the plastic bag with the other lumps.

4b. Write down how you made the 35 g lump.

I put the 20g ~~two~~ weight on a trey with the 15 g lump I just made. I kept putting plasticine on the other empty trey until they were even, so the lump would weigh 35g

**ADMINISTRATOR'S MEASUREMENTS**

| | 4a | 1a | 3a | 2a |
|---|---|---|---|---|
| Expected | 35 | 20 | 15 | 10 |
| Actual | 35 | 19 | 15 | 10 |

**HAND IN THE BAG WITH THE LUMPS OF PLASTICINE YOU HAVE WEIGHED.**
**MAKE SURE YOUR NAME IS ON THE BAG**

**LEAVE EVERYTHING ELSE AS YOU FOUND IT.**

page 3 TASK SM2-P2

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1a - Weigh a 20 g lump of plasticine.** Lump has correct mass (20 ± 2 g). (Based on administrator measurement.)
*Total Possible Points: 1*

**Item 1b - Describe strategy for making 20 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

**Item 2a - Weigh a 10 g lump of plasticine.** Lump has correct mass (10 ± 2 g). (Based on administrator measurement.)
*Total Possible Points: 2*

**Item 2b - Describe strategy for making 10 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

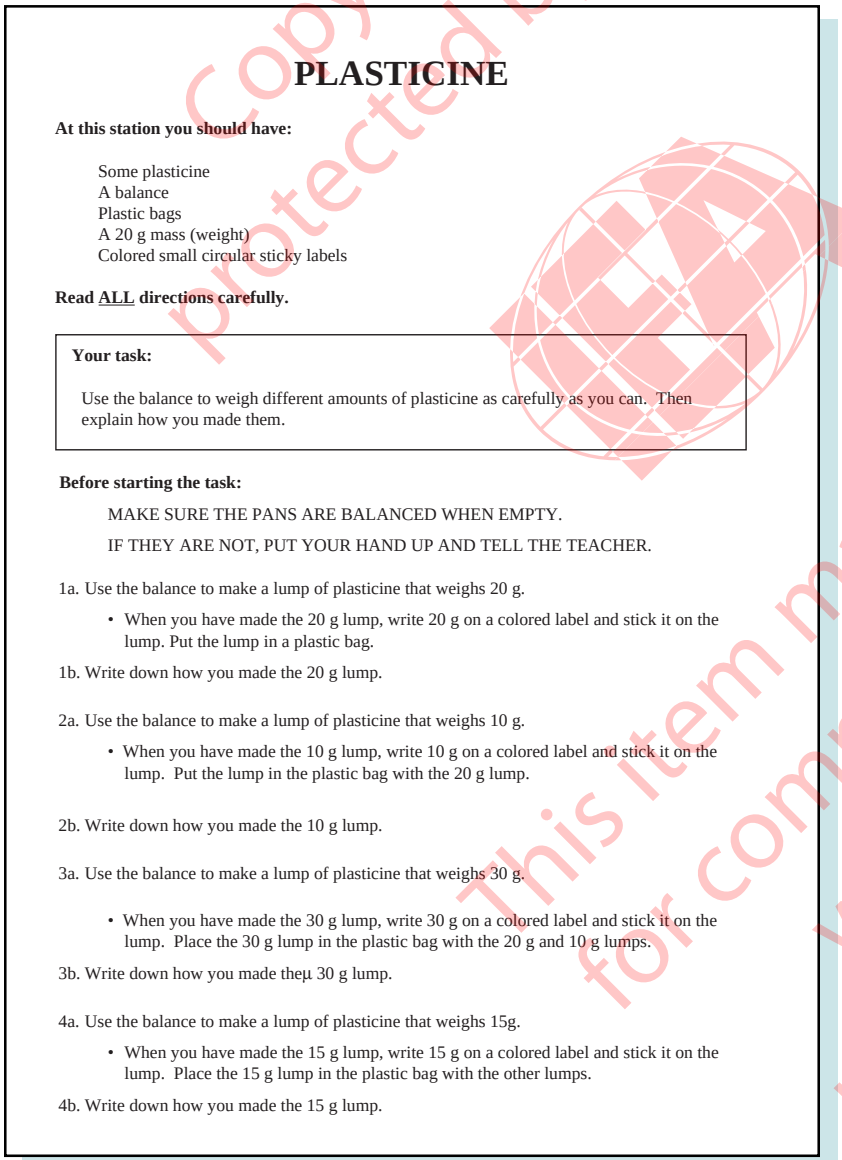
**Item 3a - Weigh a 15 g lump of plasticine.** Lump has correct mass (15 ± 3 g). (Based on administrator measurement.)
*Total Possible Points: 1*

**Item 3b - Describe strategy for making 15 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

**Item 4a - Weigh a 35 g lump of plasticine.** Lump has correct mass (35 ± 3 g). (Based on administrator measurement.)
*Total Possible Points: 2*

**Item 4b - Describe strategy for making 35 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points:2*

# FIGURE 1.13 - PLASTICINE ITEMS AND SCORING CRITERIA – FOURTH GRADE



**PLASTICINE**

**At this station you should have:**

Some plasticine
A balance
Plastic bags
A 20 g mass (weight)
Colored small circular sticky labels

**Read ALL directions carefully.**

**Your task:**

Use the balance to weigh different amounts of plasticine as carefully as you can. Then explain how you made them.

**Before starting the task:**

MAKE SURE THE PANS ARE BALANCED WHEN EMPTY.

IF THEY ARE NOT, PUT YOUR HAND UP AND TELL THE TEACHER.

1a. Use the balance to make a lump of plasticine that weighs 20 g.

- When you have made the 20 g lump, write 20 g on a colored label and stick it on the lump. Put the lump in a plastic bag.

1b. Write down how you made the 20 g lump.

2a. Use the balance to make a lump of plasticine that weighs 10 g.

- When you have made the 10 g lump, write 10 g on a colored label and stick it on the lump. Put the lump in the plastic bag with the 20 g lump.

2b. Write down how you made the 10 g lump.

3a. Use the balance to make a lump of plasticine that weighs 30 g.

- When you have made the 30 g lump, write 30 g on a colored label and stick it on the lump. Place the 30 g lump in the plastic bag with the 20 g and 10 g lumps.

3b. Write down how you made the 30 g lump.

4a. Use the balance to make a lump of plasticine that weighs 15g.

- When you have made the 15 g lump, write 15 g on a colored label and stick it on the lump. Place the 15 g lump in the plastic bag with the other lumps.

4b. Write down how you made the 15 g lump.

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1a - Weigh a 20 g lump of plasticine.** Lump has correct mass (20 ± 2 g). (Based on administrator measurement.)
*Total Possible Points: 1*

**Item 1b - Describe strategy for making 20 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

**Item 2a - Weigh a 10 g lump of plasticine.** Lump has correct mass (10 ± 2 g). (Based on administrator measurement.)
*Total Possible Points: 2*

**Item 2b - Describe strategy for making 10 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

**Item 3a - Weigh a 30 g lump of plasticine.** Lump has correct mass (30 ± 3 g). (Based on administrator measurement.)
*Total Possible Points: 1*

**Item 3b - Describe strategy for making 30 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points: 2*

**Item 4a - Weigh a 15 g lump of plasticine.** Lump has correct mass (15 ± 3 g). (Based on administrator measurement.)
*Total Possible Points: 2*

**Item 4b - Describe strategy for making 15 g lump of plasticine.** i) Method includes use of balance. ii) Method plausible for obtaining desired mass.
*Total Possible Points:2*

Task layout condensed for display

# Table 1.13 PlasticineTask: Average Percentage Score on Items – Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Item 1A Weigh 20g Lump | Item 1B Describe Strategy 20g Lump | Item 2A Weigh 10g Lump | Item 2B Describe Strategy 10g Lump | Item 3A Weigh 15g Lump | Item 3B Describe Strategy 15g Lump | Item 4A Weigh 35g Lump | Item 4B Describe Strategy 35g Lump |
| | | 1 Points | 2 Points | 2 Points | 2 Points | 1 Points | 2 Points | 2 Points | 2 Points |
| Iran, Islamic Rep. | 81 (2.6) | 93 (2.4) | 97 (1.2) | 91 (4.2) | 79 (2.5) | 92 (2.7) | 72 (3.6) | 64 (5.1) | 63 (6.7) |
| †1 Switzerland | 73 (2.1) | 98 (1.3) | 88 (2.0) | 82 (3.9) | 71 (3.2) | 71 (4.8) | 50 (3.7) | 62 (3.8) | 60 (3.7) |
| Sweden | 72 (2.9) | 88 (3.5) | 97 (1.0) | 80 (3.5) | 69 (3.1) | 73 (4.3) | 51 (4.6) | 57 (5.4) | 58 (4.4) |
| Czech Republic | 68 (2.6) | 95 (2.1) | 96 (1.9) | 74 (4.1) | 62 (3.5) | 65 (4.1) | 44 (4.0) | 58 (4.9) | 51 (6.0) |
| Norway | 67 (2.3) | 99 (0.9) | 92 (1.7) | 74 (4.1) | 62 (3.7) | 64 (3.9) | 38 (3.7) | 54 (3.9) | 50 (3.5) |
| Singapore | 66 (3.3) | 99 (0.7) | 82 (2.7) | 65 (5.2) | 60 (4.9) | 64 (5.6) | 44 (3.9) | 60 (4.7) | 53 (4.0) |
| Canada | 65 (1.9) | 93 (2.0) | 86 (2.1) | 68 (2.9) | 58 (3.1) | 71 (3.6) | 40 (3.9) | 54 (3.4) | 49 (2.9) |
| New Zealand | 63 (2.2) | 98 (0.9) | 94 (1.7) | 56 (3.4) | 52 (3.0) | 64 (2.5) | 36 (3.5) | 51 (3.7) | 52 (3.7) |
| † Scotland | 61 (2.5) | 94 (2.6) | 85 (3.0) | 59 (4.1) | 47 (4.1) | 70 (3.3) | 39 (4.0) | 53 (4.5) | 41 (4.2) |
| Cyprus | 52 (2.4) | 91 (3.3) | 83 (3.2) | 57 (3.4) | 45 (3.7) | 55 (4.7) | 19 (4.1) | 33 (5.3) | 32 (4.1) |
| Spain | 45 (2.5) | 79 (4.1) | 78 (3.4) | 48 (4.6) | 36 (4.0) | 51 (4.9) | 20 (3.2) | 29 (4.2) | 23 (3.1) |
| Portugal | 41 (2.5) | 95 (2.3) | 82 (2.0) | 47 (5.4) | 38 (5.0) | 22 (4.5) | 15 (3.5) | 15 (3.2) | 13 (2.7) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | | | |
| Australia | 73 (2.9) | 97 (1.9) | 94 (1.6) | 73 (4.0) | 69 (4.2) | 71 (4.1) | 60 (5.2) | 57 (4.7) | 64 (4.4) |
| 2 England | 55 (2.4) | 93 (2.5) | 85 (2.1) | 44 (3.7) | 42 (3.6) | 57 (4.8) | 29 (2.8) | 41 (4.9) | 48 (3.3) |
| Netherlands | 44 (2.5) | 95 (1.2) | 80 (3.7) | 35 (4.0) | 29 (3.2) | 31 (4.4) | 17 (2.9) | 29 (4.6) | 38 (4.8) |
| United States | 53 (2.1) | 91 (2.4) | 65 (2.8) | 50 (4.0) | 34 (3.2) | 76 (3.1) | 24 (2.6) | 46 (3.9) | 40 (3.5) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | | | |
| Colombia | 41 (2.7) | 89 (3.0) | 59 (3.7) | 45 (5.4) | 29 (4.2) | 46 (4.8) | 21 (4.1) | 21 (4.4) | 22 (4.0) |
| 3 Romania | 63 (4.1) | 97 (1.7) | 96 (1.7) | 64 (6.1) | 55 (4.8) | 56 (6.4) | 47 (5.6) | 45 (7.1) | 43 (5.8) |
| Slovenia | 63 (1.9) | 94 (1.9) | 87 (3.0) | 78 (3.3) | 45 (4.1) | 64 (4.1) | 34 (3.5) | 59 (3.7) | 46 (4.7) |
| **International Average** | 60 (0.6) | 93 (0.5) | 86 (0.6) | 63 (1.0) | 52 (0.9) | 61 (1.0) | 37 (0.9) | 47 (1.0) | 44 (1.0) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.
2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).
3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Plasticine Task: Average Percentage Score on Items – Fourth Grade* Table 1.14

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **Item 1A** Weigh 20g Lump | **Item 1B** Describe Strategy 20g Lump | **Item 2A** Weigh 10g Lump | **Item 2B** Describe Strategy 10g Lump | **Item 3A** Weigh 30g Lump | **Item 3B** Describe Strategy 30g Lump | **Item 4A** Weigh 15g Lump | **Item 4B** Describe Strategy 15g Lump |
| | | **1 Point** | **2 Points** | **2 Points** | **2 Points** | **1 Points** | **2 Points** | **1 Point** | **2 Points** |
| Iran, Islamic Rep. | 63 (3.3) | 89 (2.8) | 63 (4.9) | 80 (3.1) | 50 (5.5) | 64 (4.1) | 47 (6.3) | 69 (4.5) | 39 (4.7) |
| Canada | 43 (1.7) | 83 (2.6) | 62 (3.6) | 37 (3.0) | 28 (2.2) | 37 (3.9) | 28 (2.7) | 52 (4.4) | 20 (2.0) |
| †1 New Zealand | 35 (2.0) | 78 (3.7) | 62 (3.9) | 24 (2.8) | 20 (2.5) | 29 (3.5) | 25 (2.9) | 28 (4.1) | 10 (1.9) |
| Cyprus | 30 (2.1) | 76 (5.5) | 40 (3.1) | 31 (4.4) | 14 (2.4) | 26 (6.7) | 16 (3.7) | 30 (5.1) | 6 (1.9) |
| Portugal | 24 (2.3) | 87 (3.6) | 46 (4.3) | 25 (5.2) | 12 (3.4) | 10 (3.3) | 10 (3.3) | 0 (0.0) | 2 (1.3) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | | | |
| Australia | 40 (2.1) | 83 (4.4) | 60 (3.9) | 42 (3.9) | 24 (3.1) | 33 (3.5) | 28 (3.7) | 34 (3.9) | 15 (1.9) |
| Hong Kong | 23 (1.7) | 66 (3.4) | 40 (4.6) | 18 (4.2) | 10 (2.7) | 18 (3.8) | 17 (3.6) | 10 (2.6) | 7 (2.0) |
| United States | 31 (1.5) | 75 (2.6) | 36 (2.9) | 30 (3.7) | 13 (2.1) | 26 (3.3) | 14 (2.3) | 47 (3.3) | 7 (1.5) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | | | |
| Slovenia | 46 (2.7) | 82 (3.5) | 61 (5.0) | 65 (4.0) | 22 (3.5) | 51 (5.3) | 28 (3.7) | 45 (4.8) | 15 (2.6) |
| **International Average** | 37 (0.7) | 80 (1.2) | 52 (1.4) | 39 (1.3) | 21 (1.1) | 33 (1.4) | 24 (1.2) | 35 (1.3) | 13 (0.8) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.

● Percent of total possible points on each item averaged over students.

▼ Average of percentage scores across items; all items weighted equally.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)

1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# DICE

In the mathematics task Dice, students were asked to explore the application of a transformation rule to a set of numbers generated by the throw of a die. Students were given a die, a shaker, and an algorithm for converting the number resulting from each throw to another number. They were asked to generate some numbers, apply the algorithm, and answer some questions about the patterns of numbers generated. Students also were provided with a table showing two examples of the transformation to be applied, and the shell of a table for recording data (the ability to construct a data table was not being assessed here). Dice is a fairly straightforward task, intended to measure students' ability to apply an arbitrary numerical algorithm, record and analyze data, and identify and explain the patterns in the data recorded. The task is identical for both populations. Scoring criteria for fully-correct responses to each item and examples of student responses are shown in Figure 1.14.

Eighth-grade students generally found the application of the algorithm easy (Table 1.15, Items 1 and 3 – average percentage score: 90%), but describing the data (Item 2 – average percentage score: 71%) and summarizing it in another table (Item 4 – average percentage score: 71%) were more difficult. Students had little difficulty extracting an item of information from the table (Item 5A – average percentage score: 83%), but providing an explanation for the pattern of data in the summary table (Item 5B – average percentage score: 33%) was much more demanding.

A similar pattern of achievement across items was found for fourth-grade students, although these students had a lower average performance level (Table 1.16 – average percentage score: 42% for fourth graders, compared with Table 1.15 average percentage score: 73% for eighth graders). The younger students also found the application of the algorithm manageable, but the less procedural questions caused them more problems. In particular, the very low scores on Item 5B reflects the difficulty noted earlier that primary-school students have in producing written explanations.

# FIGURE 1.14 - DICE

## FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH AND FOURTH GRADES

### ITEM 1

**DICE**

**At this station you should have:**

One of a pair of dice (This is called a die.)
A shaker

**Read ALL directions carefully.**

**Your task:**

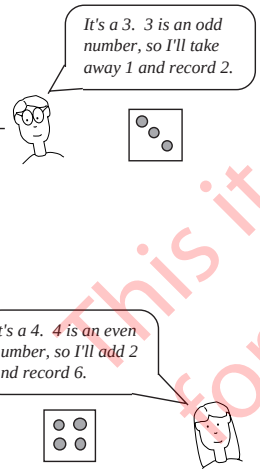
Find out what happens when we use a rule to change the numbers that turn up when a die is thrown.

**The rule for changing the numbers is:**

- If an ODD number turns up, take away 1 and record the result.
- If an EVEN number turns up, add 2 and record the result.

1. In the table below, two examples have already been recorded for you. Use the rule to find out what the other changed numbers will be. Complete the table.

| Number on die | Changed numbers |
|---|---|
| 1 | 0 |
| 2 | 4 |
| 3 | 2 |
| 4 | 6 |
| 5 | 4 |
| 6 | 8 |




page 1 TASK M1-P2

### ITEMS 2 AND 3

2. What do you notice about the numbers you recorded?

All the numbers, once we've used the rule come out as an even number

3. Throw the die 30 times. Each time you throw the die change the numbers that turn up using the rule. Each time record the number on the die and the changed numbers. Write the numbers in the tables below.

| Number on die | Changed number |
|---|---|
| 5 | 4 |
| 6 | 8 |
| 5 | 4 |
| 3 | 2 |
| 1 | 0 |
| 4 | 6 |
| 3 | 2 |
| 4 | 6 |
| 2 | 4 |
| 2 | 4 |
| 4 | 6 |
| 5 | 4 |
| 4 | 6 |
| 1 | 0 |
| 6 | 8 |

| Number on die | Changed number |
|---|---|
| 4 | 6 |
| 1 | 0 |
| 2 | 4 |
| 6 | 8 |
| 6 | 8 |
| 4 | 6 |
| 3 | 2 |
| 5 | 4 |
| 2 | 4 |
| 4 | 6 |
| 5 | 4 |
| 6 | 8 |
| 6 | 8 |
| 4 | 6 |
| 3 | 2 |

**Please turn the page.**

TASK M1-P2 page 2

## ITEM 4 AND 5

4. Look again at the table you filled in for question number 3. How many times did you record each of the following numbers in the "Changed Number" column?

| Changed Number | Number of Times Recorded |
|---|---|
| 0 | 3 |
| 1 | 0 |
| 2 | 4 |
| 3 | 0 |
| 4 | 9 |
| 5 | 0 |
| 6 | 8 |
| 7 | 0 |
| 8 | 6 |

5a. What changed number did you record most? 4 (fours)

5b. Why did it happen this way?

Because twos (2) and fives (5) both get changed into a 4, when using the rule

**PUT YOUR MATERIALS BACK THE WAY YOU FOUND THEM SO THAT SOMEONE ELSE CAN USE THIS STATION.**

page 3 TASK M1-P2

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Change numbers according to algorithm to complete table.**
Applies algorithm correctly (0, 4, 2, 6, 4, 8).
*Total Possible Points: 2*

**Item 2 - Identify and describe pattern in numbers.**
i) Describes pattern that is consistent with data. ii) Patterns and trends may be one or more of the following: all numbers are even; numbers range from 0 to 8; number 4 occurs twice; rule for obtaining sequential numbers, such as +4, -2, +4, -2.
*Total Possible Points: 1*

**Item 3 - Apply algorithm to die throws and record resulting numbers in table.** i) Completes at least 25 throws of die. ii) Applies algorithm correctly.
*Total Possible Points: 2*

**Item 4 - Count frequency of each changed number recorded in table.** Response consistent with data table.
*Total Possible Points: 2*

**Item 5a - Identify most frequently recorded number in table.**
Response is consistent with data.
*Total Possible Points: 1*

**Item 5b - Explain most frequently recorded number in table.**
Provides plausible explanation to account for the predominance of observed number.
*Total Possible Points: 1*

# Table 1.15 Dice Task: Average Percentage Score on Items – Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | |
|---|---|---|---|---|---|---|---|
| | | Item 1 Complete Table | Item 2 Describe Pattern | Item 3 Apply Algorithm | Item 4 Count Frequencies | Item 5A Identify Most Frequent Number | Item 5B Explain Findings |
| | | 2 Points | 1 Point | 2 Points | 2 Points | 1 Point | 1 Point |
| Singapore | 84 (1.6) | 97 (1.0) | 90 (2.8) | 95 (1.9) | 84 (2.1) | 95 (2.1) | 44 (6.1) |
| †1 Switzerland | 79 (1.4) | 91 (1.9) | 86 (3.8) | 94 (1.4) | 69 (3.0) | 86 (2.8) | 45 (4.1) |
| Canada | 77 (1.8) | 92 (2.0) | 84 (3.2) | 90 (1.7) | 75 (3.0) | 88 (2.3) | 31 (3.1) |
| † Scotland | 76 (1.6) | 93 (1.5) | 73 (3.3) | 93 (1.0) | 70 (2.7) | 87 (2.0) | 41 (4.6) |
| Portugal | 76 (1.8) | 96 (1.3) | 67 (4.5) | 97 (1.2) | 72 (3.2) | 85 (2.9) | 38 (4.9) |
| Sweden | 74 (2.4) | 94 (1.7) | 65 (4.7) | 92 (2.3) | 71 (3.7) | 81 (3.2) | 44 (4.7) |
| Czech Republic | 73 (2.5) | 93 (2.1) | 75 (5.2) | 83 (3.1) | 73 (3.3) | 78 (3.7) | 39 (4.7) |
| New Zealand | 73 (1.2) | 94 (1.2) | 76 (2.4) | 93 (1.3) | 63 (2.4) | 83 (2.6) | 31 (3.5) |
| Spain | 73 (2.2) | 88 (2.4) | 68 (3.4) | 90 (2.4) | 68 (3.2) | 83 (3.7) | 43 (5.2) |
| Norway | 72 (1.9) | 94 (2.4) | 70 (4.5) | 89 (2.2) | 65 (3.5) | 87 (2.8) | 30 (4.5) |
| Cyprus | 68 (2.2) | 83 (2.6) | 67 (4.3) | 90 (2.4) | 65 (3.2) | 77 (4.8) | 28 (4.7) |
| Iran, Islamic Rep. | 58 (1.8) | 83 (3.8) | 34 (3.7) | 78 (3.8) | 72 (6.1) | 73 (4.1) | 9 (3.2) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | |
| Australia | 78 (2.4) | 94 (1.4) | 74 (4.5) | 93 (1.6) | 76 (3.2) | 89 (2.9) | 44 (4.9) |
| 2 England | 79 (1.6) | 97 (1.2) | 83 (2.8) | 93 (1.9) | 73 (2.5) | 90 (3.0) | 38 (3.9) |
| Netherlands | 76 (2.2) | 97 (1.1) | 82 (7.1) | 96 (1.6) | 72 (3.3) | 87 (2.9) | 21 (3.7) |
| United States | 71 (2.1) | 89 (2.6) | 76 (3.1) | 88 (2.2) | 69 (3.1) | 77 (2.8) | 29 (3.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | |
| Colombia | 49 (4.0) | 68 (4.2) | 41 (6.8) | 70 (4.9) | 52 (4.5) | 60 (8.4) | 6 (1.8) |
| 3 Romania | 76 (2.3) | 67 (6.2) | 73 (4.4) | 95 (2.0) | 88 (3.1) | 88 (3.0) | 42 (5.2) |
| Slovenia | 78 (1.4) | 98 (1.1) | 72 (3.9) | 99 (1.0) | 80 (3.0) | 89 (2.8) | 33 (4.3) |
| **International Average** | 73 (0.5) | 90 (0.6) | 71 (1.0) | 90 (0.5) | 71 (0.8) | 83 (0.8) | 33 (1.0) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.
2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).
3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Dice Task: Average Percentage Score on Items – Fourth Grade* Table 1.16

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | |
|---|---|---|---|---|---|---|---|
| | | Item 1 Complete Table | Item 2 Describe Pattern | Item 3 Apply Algorithm | Item 4 Count Frequencies | Item 5A Identify Most Frequent Number | Item 5B Explain Findings |
| | | 2 Points | 1 Point | 2 Points | 2 Points | 1 Point | 1 Point |
| Canada | 46 (2.8) | 77 (2.9) | 41 (3.4) | 63 (5.5) | 40 (4.0) | 48 (4.3) | 5 (1.1) |
| †1 New Zealand | 39 (2.4) | 67 (3.8) | 31 (3.6) | 65 (3.5) | 27 (3.1) | 42 (3.7) | 5 (1.8) |
| Cyprus | 39 (2.4) | 71 (4.3) | 22 (4.2) | 60 (4.6) | 35 (2.5) | 36 (3.8) | 10 (3.0) |
| Iran, Islamic Rep. | 34 (2.9) | 64 (4.9) | 16 (3.8) | 57 (5.0) | 29 (3.8) | 28 (4.6) | 8 (2.9) |
| Portugal | 28 (2.6) | 72 (4.1) | 21 (4.0) | 41 (4.9) | 14 (2.8) | 16 (3.3) | 4 (1.7) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | |
| Australia | 54 (1.9) | 81 (2.7) | 45 (3.8) | 71 (4.3) | 54 (2.9) | 58 (3.0) | 16 (2.4) |
| Hong Kong | 48 (3.8) | 82 (3.9) | 30 (4.8) | 71 (6.5) | 38 (5.4) | 51 (4.5) | 13 (2.8) |
| United States | 45 (2.4) | 71 (3.1) | 43 (3.1) | 68 (3.7) | 31 (3.4) | 47 (5.1) | 7 (2.2) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | |
| Slovenia | 44 (2.5) | 77 (3.7) | 26 (4.1) | 64 (4.4) | 39 (3.7) | 50 (4.8) | 9 (2.0) |
| **International Average** | 42 (0.9) | 73 (1.3) | 31 (1.3) | 62 (1.6) | 34 (1.2) | 42 (1.4) | 9 (0.8) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# CALCULATOR

In the Calculator task, students were provided with a calculator and asked to use it to perform multiplications to explore a number pattern. The numbers to be multiplied – 34 x 34, 334 x 334, and 3334 x 3334 – were such as to yield a clear and interesting pattern in the products. At eighth-grade, students also were asked to work on factoring a given number. The task was intended to measure a student's ability to use the calculator for multiplication, to analyze a pattern in the results, to make predictions from the pattern found, to explain the basis for the predictions, and (at the eighth-grade level) to use prior knowledge of number properties to find factors for a given number. Solving the factoring problem, in which students were asked to find two factors of 455 such that both factors were two-digit numbers and were less than 50, required some knowledge of number properties and was greatly facilitated if students understood the concept of prime factors. Figure 1.15 shows the task with sample responses to all seven items, and the scoring criteria for fully-correct responses. The task was identical for both grades, except that the fourth-grade students were not given the factoring problem.

Eighth-grade students almost universally were able to use the calculator to carry out the required multiplications (Table 1.17, Item 1 – average percentage score: 97%), but they were much less successful in describing the underlying pattern (Item 2 – average percentage score: 40%). Interestingly, despite rather low performance on the description item, students were generally successful in applying the pattern to solve a routine problem. That is, they predicted the next number in the sequence (Item 3 – average percentage score: 75%). This coincides with the commonsense notion that students' ability to understand and to apply their knowledge generally exceeds their ability to describe what it is they know. Eighth graders were less successful in applying the pattern to a less routine situation, i.e., predicting a number further out in the sequence (Item 4 – average percentage score: 55%). Errors in this situation tended to involve incomplete pattern analyses. In attempting to explain their predictions (Item 5 – average percentage score: 42%), a substantial number of students simply made a comment that took the explanation for granted; e.g., "They were easy if you found the method."

The two questions on factoring (eighth grade only) addressed content and procedures quite different from those of the previous items, but were grouped with them because the calculator was useful in discovering or verifying factors. Eighth-graders found it moderately difficult to give three reasons why a particular pair of numbers could not be the missing factors (Item 6 – average percentage score for part one: 45%). About one-fifth were able to find the factors themselves (Item 6 – average percentage score for part two: 21%). Of the students not receiving full credit, some showed the correct factors, but omitted evidence of their work; others gave non-integral numbers as the factors, or tried factors at random.

Fourth-grade students also proved accomplished in using the calculator for multiplication (Table 1.18, Item 1 – average percentage score: 92%), and many could use the pattern to predict the next number in the sequence (Item 3 – average percentage score: 52%). However, describing the number pattern, applying it in a less routine situation, and explaining how they made their predictions were generally very difficult for the fourth graders.

# FIGURE 1.15 - CALCULATOR FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH AND FOURTH GRADES

## ITEMS 1 AND 2

### CALCULATOR

**At this station you should have:**

A calculator

**Your task:**

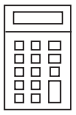
Use a calculator to help you explore a number pattern, and to find missing numbers.

**Before answering the questions read these notes:**

When you use the calculator:

- Make sure that you press the correct keys.
- Make sure that you read the display carefully.

1. Use the calculator to find the answers to these multiplications.



$34 \times 34 =$ 1156

$334 \times 334 =$ 111556

$3334 \times 3334 =$ 11115556

2. What do you notice about the multiplications and the pattern of answers?

Everytime, the number being multiplied has an extra 3 at the beginning. The answers all have the same numbers in them. There is always a 6 at the end, the number of 5's in the answer is the number of 3's in the number being multiplied. The number of 1's in the answer increases with each 3 added to the number being multiplied.



## ITEMS 3, 4, AND 5

3. Now use the pattern to write down what you think the answer will be to the multiplication below WITHOUT using the calculator.

$33334 \times 33334 =$ 1111155556

4. Now write down what you think the answer will be to the multiplication below WITHOUT using the calculator.

$3333334 \times 3333334 =$ 11111115555556

5. How did you figure out the answer to questions 3 and 4?

I looked on the pattern I noticed earlier

**Please turn the page.**

## ITEM 6 (EIGHTH GRADE ONLY)


6. Ramesh tells Alison that he multiplied two whole numbers together using a calculator and the answer was 455, but he's forgotten the numbers. He can remember two things about them:

   - both numbers had 2 digits
   - both numbers were less than 50

   Alison tries several numbers. She began by putting 7 ¥ 64 into the calculator. But Ramesh said, "I can give you at least three reasons why those numbers can't be the ones I used." What were Ramesh's reasons?

   a. both number have to be less than 50 – 64 isn't

   b. both numbers have 2 digits – 7 doesn't

   c. if the answer is 455 then one of the digits has to end in 5

   After thinking a bit about the problem, Alison made some more tries and found the two numbers.

   - Now you try to find the numbers Alison found.

   You may use any method you like. Write down each of your tries here.

   15 x 20 = 300
   15 x 30 = 450
   15 x 31 = 465
   35 x 12 = 420
   35 x 15 = 525
   35 x 13 = 455

page 3 TASK M2-P2

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Use calculator to perform multiplications.**
All 3 calculations correct (1156, 111556, 11115556).
*Total Possible Points: 3*

**Item 2 - Identify pattern in answers.** i) Identifies a correct pattern. ii) Includes the repetitions of 1, 5, and may include 6. iii) Identifies a relationship between these and the increasing number of digits or the increasing numbers of 3 in the multipliers.
*Total Possible Points: 2*

**Item 3 - Predict answer to first (routine) calculation.** Predicts answer based on application of correct pattern (1111155556).
*Total Possible Points: 2*

**Item 4 - Predict answer to second (non-routine) calculation.** Predicts answer based on application of correct pattern (11111115555556).
*Total Possible Points: 2*

**Item 5 - Describe strategy for predicting answers.** Describes pattern and a correct method of application.
*Total Possible Points: 2*

**Item 6 - Factors of 455.** Responses to two parts are scored separately.

**List three reasons why Alison's factors are incorrect.** Lists 3 of the following, or other correct reasons: 7 is not a two-digit number; 64 is more than 50; 64 is an even number so the product will be even; neither 7 nor 64 is a multiple of 5.
*Total Possible Points: 3*

**Find correct factors.** i) Identifies correct factors (35 x 13). ii) Shows use of a systematic method.
*Total Possible Points: 2*

# Table 1.17 Calculator Task: Average Percentage Score on Items – Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Item 1 Perform Calculations | Item 2 Identify Pattern | Item 3 Predict: Routine Application | Item 4 Predict: Non-Routine Application | Item 5 Explain Predictions | Item 6 Factors of 455 | |
| | | | | | | | Reasons Factors Incorrect | Find Correct Factors |
| | | 3 Points | 2 Points | 2 Points | 2 Points | 2 Points | 3 Points | 2 Points |
| †1 Switzerland | 61 (1.6) | 99 (0.5) | 51 (3.4) | 85 (2.8) | 64 (3.8) | 55 (3.9) | 40 (3.6) | 33 (3.7) |
| Singapore | 60 (2.8) | 98 (0.7) | 33 (4.3) | 84 (3.3) | 64 (5.1) | 45 (4.9) | 53 (3.4) | 45 (4.2) |
| Canada | 60 (1.5) | 97 (0.8) | 44 (2.7) | 86 (2.2) | 64 (2.7) | 47 (2.8) | 50 (2.6) | 30 (1.7) |
| Norway | 59 (1.6) | 99 (0.5) | 44 (2.7) | 79 (3.2) | 51 (3.2) | 46 (3.2) | 69 (2.7) | 25 (3.2) |
| New Zealand | 55 (1.5) | 95 (1.2) | 43 (2.5) | 78 (2.9) | 56 (3.2) | 40 (3.2) | 47 (2.0) | 24 (2.2) |
| Czech Republic | 54 (2.0) | 96 (1.7) | 45 (3.9) | 76 (3.2) | 58 (5.0) | 45 (3.7) | 44 (3.8) | 15 (3.4) |
| Spain | 53 (2.1) | 98 (0.6) | 48 (4.6) | 76 (4.0) | 53 (5.4) | 53 (3.6) | 29 (2.6) | 12 (2.2) |
| Sweden | 51 (2.3) | 95 (1.2) | 40 (4.4) | 69 (3.7) | 52 (3.2) | 49 (4.5) | 39 (3.9) | 10 (2.4) |
| † Scotland | 49 (3.1) | 97 (0.7) | 44 (4.8) | 65 (4.9) | 43 (6.0) | 45 (4.5) | 35 (3.3) | 15 (3.3) |
| Iran, Islamic Rep. | 48 (3.7) | 96 (2.0) | 43 (6.0) | 59 (7.0) | 54 (7.3) | 30 (4.8) | 51 (3.5) | 6 (3.7) |
| Cyprus | 40 (1.9) | 97 (0.8) | 24 (3.6) | 56 (3.6) | 39 (3.9) | 19 (2.9) | 38 (3.5) | 9 (1.9) |
| Portugal | 39 (2.1) | 95 (2.0) | 23 (3.3) | 62 (5.0) | 44 (4.7) | 26 (2.9) | 21 (3.6) | 5 (1.3) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | | |
| Australia | 59 (1.9) | 99 (0.3) | 50 (4.6) | 86 (2.2) | 67 (3.9) | 50 (4.3) | 36 (2.9) | 27 (4.0) |
| 2 England | 62 (1.4) | 98 (0.7) | 50 (3.1) | 85 (2.9) | 59 (4.1) | 61 (2.5) | 53 (2.4) | 29 (2.5) |
| Netherlands | 59 (2.3) | 97 (1.0) | 37 (3.8) | 77 (3.6) | 58 (4.5) | 42 (3.0) | 78 (3.5) | 25 (3.4) |
| United States | 56 (1.9) | 97 (0.8) | 44 (3.5) | 79 (3.1) | 51 (2.7) | 44 (3.4) | 54 (3.1) | 20 (2.8) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | | |
| Colombia | 31 (1.6) | 94 (1.7) | 20 (2.9) | 46 (4.6) | 27 (3.4) | 10 (1.8) | 13 (2.8) | 6 (1.9) |
| 3 Romania | 66 (2.6) | 98 (1.1) | 51 (4.4) | 82 (4.0) | 79 (4.3) | 57 (4.8) | 48 (3.4) | 44 (5.1) |
| Slovenia | 58 (1.6) | 99 (0.5) | 34 (4.2) | 84 (2.4) | 68 (3.1) | 35 (3.0) | 61 (3.5) | 23 (3.2) |
| **International Average** | 54 (0.5) | 97 (0.3) | 40 (0.9) | 75 (0.9) | 55 (1.0) | 42 (0.8) | 45 (0.7) | 21 (0.7) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.

● Percent of total possible points on each item averaged over students.

▼ Average of percentage scores across items; all items weighted equally.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)

1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.

2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).

3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Calculator Task: Average Percentage Score on Items – Fourth Grade* Table 1.18

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | |
|---|---|---|---|---|---|---|
| | | **Item 1** Perform Calculations | **Item 2** Identify Pattern | **Item 3** Predict: Routine Application | **Item 4** Predict: Non-Routine Application | **Item 5** Explain Predictions |
| | | **3 Points** | **2 Points** | **2 Points** | **2 Points** | **2 Points** |
| Canada | 47 (2.0) | 94 (1.3) | 22 (2.6) | 64 (3.3) | 30 (3.1) | 24 (2.5) |
| †1 New Zealand | 40 (1.7) | 94 (1.6) | 15 (2.1) | 57 (4.4) | 23 (2.8) | 12 (1.4) |
| Iran, Islamic Rep. | 35 (2.9) | 74 (4.5) | 14 (3.5) | 44 (3.6) | 33 (3.6) | 11 (2.6) |
| Portugal | 33 (2.0) | 95 (0.9) | 7 (2.1) | 41 (4.4) | 14 (3.9) | 7 (1.8) |
| Cyprus | 31 (2.5)** | 93 (1.8) | 5 (2.2) | 30 (5.4) | 18 (4.6) | - - |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | |
| Australia | 43 (2.5) | 95 (1.5) | 11 (1.7) | 62 (4.6) | 31 (5.0) | 15 (2.4) |
| Hong Kong | 50 (2.5) | 94 (1.4) | 23 (3.9) | 74 (4.6) | 46 (5.0) | 15 (4.2) |
| United States | 42 (2.2) | 95 (0.9) | 19 (2.7) | 56 (4.1) | 23 (3.8) | 17 (1.9) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | |
| Slovenia | 37 (1.9) | 95 (2.1) | 10 (2.4) | 44 (5.3) | 23 (3.8) | 11 (1.5) |
| **International Average** | 40 (0.8) | 92 (0.7) | 14 (0.9) | 52 (1.5) | 27 (1.3) | 13 (0.8) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.

● Percent of total possible points on each item averaged over students.

▼ Average of percentage scores across items; all items weighted equally.

A dash (-) indicates data are not available. Item 5 was not administered in Cyprus.

**Overall task average includes an estimated average percentage score of 7% for Item 5 based on overall relative country performance and international item difficulty.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)

1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# FOLDING & CUTTING

For the Folding and Cutting task, students were given scissors and a number of sheets of paper, and asked to fold and cut the paper so as to duplicate a set of cutout shapes. They were allowed up to three tries to duplicate each shape, but no additional credit was given for fewer attempts. The task was intended to measure understanding of symmetry and spatial relations, and the ability to solve problems in a non-routine situation, i.e., in a spatial context. The task was the same for the fourth and eighth grades, except for an extra item for the eighth-grade students.

Figure 1.16 shows the tasks and sample student responses, together with scoring criteria for fully-correct responses to each item. Items 1, 2, and 3 make use of the same problem (although it is presented in increasing complexity), draw on the same ability, and are coded according to the same rubric. Item 4 (eighth grade only) asks students to draw the lines where the folds would be in order to achieve the shape provided, without actually manipulating the scissors and paper.

In general, eighth-grade students were quite successful in performing the three folding and cutting exercises (Table 1.19, Items 1-3). International average percentage scores on these items were in the 70s. It is perhaps not surprising that international averages for these items do not differ greatly, since they required essentially the same thinking and manipulative skills and addressed a common problem, albeit with varying degrees of complexity. In the fourth item no manipulation was required, but rather students were asked to think about how to fold the paper and to draw lines on the diagram to show where the folds should be. The drop in performance on Item 4 (average percentage score: 53%) compared with the first three items may be due partly to the more complex pattern, but also seems to illustrate the importance of hands-on materials for problem solving among middle-school students.

As might be expected, the fourth-grade students found the cutting and folding tasks more difficult, with average percentage scores in the 30s and 40s (Table 1.20).

# FIGURE 1.16 - FOLDING AND CUTTING FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH AND FOURTH GRADES

## ITEM 1

### FOLDING AND CUTTING

**At this station you should have:**

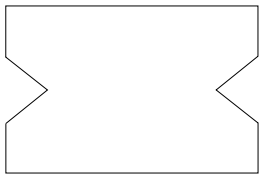
9 sheets of paper.
Scissors
An envelope

**Your task:**

Fold and cut sheets of paper to make shapes which match the patterns given. For each shape you may fold the paper as often as you like, but ONLY ONE straight cut is allowed.

1. Look at shape number 1 below. Fold a sheet of paper as many times as necessary and make ONE STRAIGHT CUT so that when the paper is unfolded it has the same SHAPE as shape number 1. The SIZE of your paper and cutouts do not have to be the same as those shown here. If you are unsuccessful, you may try again with another sheet of paper. You may try this task a total of THREE times.
   - Write number 1 on each sheet of paper you used for this task.
   - Write your first name on each sheet.

**Shape 1**

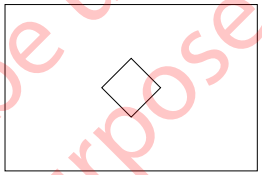


page 1 TASK M3-P2

## ITEMS 2 AND 3

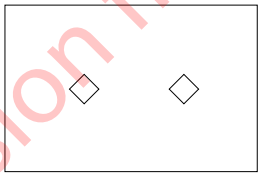
2. Do the same for shape 2. Remember only ONE STRAIGHT CUT is allowed. You may try this task a total of THREE times.
   - Write the number 2 on each sheet of paper you used for this task.
   - Write your first name on each sheet

**Shape 2**



3. Do the same for shape 3. Remember only ONE STRAIGHT CUT is allowed. You may try this task a total of THREE times.
   - Write number 3 on each sheet of paper you used for this task.
   - Write your first name on each sheet.

**Shape 3**



**Please turn the page.**

TASK M3-P2 page 2

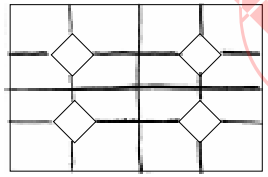
## ITEM 4 (EIGHTH GRADE ONLY)

4. For this question, shape 4 is drawn below. Instead of folding or cutting shape 4, you are asked to THINK about how to get the pattern by folding a piece of paper and making one straight cut. DON'T FOLD OR CUT ANY PAPER FOR THIS QUESTION.

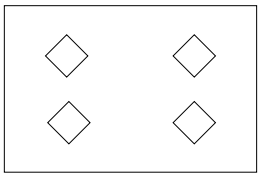
   Instead draw on the diagram below the LINES you would see on a piece of paper that had been folded and cut.

   Two copies of shape 4 are drawn here in case you are not satisfied with your first attempt and wish to try again. Remember, only draw lines to show where the paper should be folded.

**Shape 4**



**Shape 4**



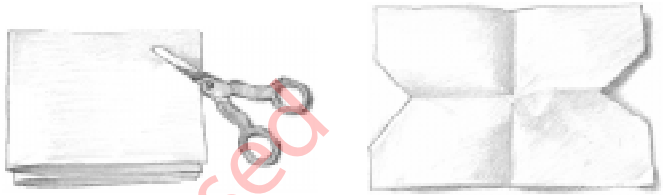
**PUT ALL YOUR SHEETS OF PAPER INTO YOUR ENVELOPE, INCLUDING YOUR UNSUCCESSFUL TRIES.**

**THROW AWAY ANY SCRAPS OF PAPER.**

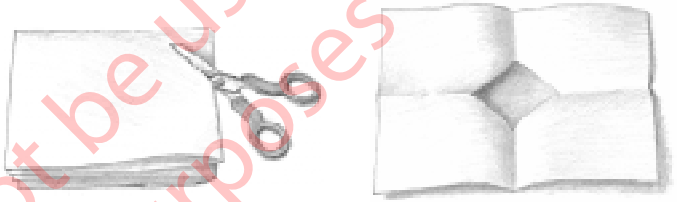
page 3 TASK M3-P2

## RESPONSES FOR ITEMS 1, 2, AND 3

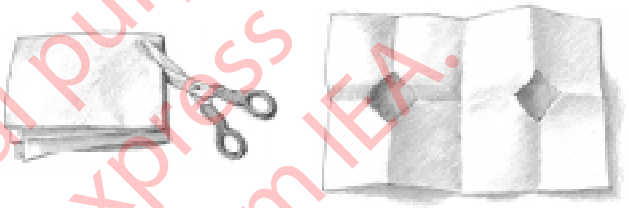
1)



2)



3)



## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Fold paper and cut out shape 1.** i) Makes only one cut line. ii) Places two fold lines correctly.
*Total Possible Points: 2*

**Item 2 - Fold paper and cut out shape 2.** i) Makes only one cut line. ii) Places two fold lines correctly.
*Total Possible Points: 2*

**Item 3 - Fold paper and cut out shape 3.** i) Makes only one cut line. ii) Places four fold lines correctly.
*Total Possible Points: 2*

**Item 4 - Predict and draw fold lines on shape 4.** Shows six fold lines in the correct locations.
*Total Possible Points: 3*

# Table 1.19 Folding and Cutting Task: Average Percentage Score on Items - Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | |
|---|---|---|---|---|---|
| | | Item 1 Fold and Cut Shape 1 | Item 2 Fold and Cut Shape 2 | Item 3 Fold and Cut Shape 3 | Item 4 Predict and Draw Shape 4 |
| | | Points 2 | Points 2 | Points 2 | Points 3 |
| Singapore | 80 (2.6) | 83 (2.3) | 86 (2.6) | 81 (3.1) | 72 (4.0) |
| Sweden | 80 (2.5) | 84 (3.0) | 88 (2.5) | 86 (2.5) | 62 (3.4) |
| †1 Switzerland | 79 (1.9) | 80 (2.8) | 89 (1.9) | 85 (1.9) | 63 (3.4) |
| New Zealand | 75 (2.3) | 75 (3.3) | 83 (2.6) | 77 (2.9) | 65 (2.2) |
| Czech Republic | 73 (3.2) | 78 (4.0) | 84 (2.6) | 75 (3.6) | 55 (5.0) |
| Norway | 73 (2.1) | 76 (3.1) | 81 (2.6) | 76 (2.9) | 59 (2.2) |
| † Scotland | 71 (3.9) | 78 (4.2) | 80 (4.1) | 74 (4.7) | 53 (5.1) |
| Spain | 61 (3.1) | 62 (3.8) | 71 (4.0) | 63 (4.4) | 50 (4.2) |
| Canada | 59 (2.5) | 60 (3.4) | 72 (3.2) | 63 (3.4) | 42 (2.7) |
| Iran, Islamic Rep. | 58 (3.0) | 57 (3.4) | 69 (3.6) | 62 (4.2) | 44 (4.0) |
| Portugal | 58 (3.1) | 59 (4.2) | 71 (4.7) | 65 (4.4) | 36 (2.5) |
| Cyprus | 48 (2.4) | 60 (3.2) | 59 (2.9) | 45 (2.6) | 27 (2.9) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | |
| Australia | 74 (3.3) | 76 (3.7) | 83 (2.9) | 77 (4.4) | 59 (4.3) |
| 2 England | 69 (3.0) | 66 (4.1) | 80 (3.6) | 69 (3.8) | 62 (2.9) |
| Netherlands | 71 (2.4) | 70 (3.5) | 79 (3.6) | 75 (3.0) | 59 (3.8) |
| United States | 68 (2.0) | 72 (2.8) | 82 (2.2) | 75 (2.1) | 45 (3.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | |
| Colombia | 43 (5.7) | 45 (7.2) | 62 (5.0) | 41 (7.1) | 25 (5.9) |
| 3 Romania | 84 (2.3) | 89 (2.0) | 91 (2.3) | 88 (2.7) | 67 (5.0) |
| Slovenia | 82 (2.0) | 83 (2.9) | 90 (1.7) | 86 (2.2) | 70 (3.2) |
| **International Average** | 69 (0.7) | 71 (0.8) | 79 (0.7) | 72 (0.8) | 53 (0.9) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.
2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).
3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Folding and Cutting Task: Average Percentage Score on Items – Fourth Grade* Table 1.20

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | |
|---|---|---|---|---|
| | | Item 1<br>Fold and Cut Shape 1 | Item 2<br>Fold and Cut Shape 2 | Item 3<br>Fold and Cut Shape 3 |
| | | Points<br>2 | Points<br>2 | Points<br>2 |
| Iran, Islamic Rep. | 50 (6.9) | 52 (7.1) | 50 (6.7) | 47 (7.6) |
| Canada | 31 (3.6) | 28 (4.2) | 36 (4.1) | 28 (3.1) |
| Cyprus | 28 (3.4) | 33 (3.7) | 30 (3.7) | 21 (3.8) |
| †1 New Zealand | 25 (3.8) | 24 (3.5) | 29 (4.2) | 23 (4.4) |
| Portugal | 21 (3.1) | 21 (4.4) | 24 (3.6) | 17 (2.9) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | |
| Australia | 40 (3.6) | 38 (3.6) | 49 (4.1) | 34 (4.3) |
| Hong Kong | 40 (4.0) | 39 (3.5) | 46 (5.8) | 35 (4.4) |
| United States | 44 (2.5) | 42 (3.1) | 51 (2.7) | 39 (3.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | |
| Slovenia | 63 (3.6) | 66 (3.7) | 67 (4.0) | 55 (4.4) |
| **International Average** | 38 (1.3) | 38 (1.4) | 42 (1.5) | 33 (1.5) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# AROUND THE BEND

For the Around the Bend task students were supplied with a model of a corridor having a right-angle bend, and several pieces of cardboard cut to represent pieces of furniture. The task, in general, was to find out which pieces of furniture would go around the bend in the corridor. The kinds of furniture and their dimensions varied across countries to suit the local contexts. For eighth-grade students, the task was intended to measure the following procedural and cognitive skills: to perform conversions between meters and centimeters; to use a scale to convert model sizes to the dimensions of real-world furniture pieces; to solve a spatial problem by manipulating models; to make judgments about the real-world furniture that the models might reasonably represent; and, finally, to generalize a rule from experimenting with models. The rule needed to relate model width and length to the dimensions of the corridor so that the furniture "would always go around the bend." Figure 1.17 presents the eighth-grade version of the task, together with sample student responses and criteria for fully-correct responses.

The fourth-grade version of the task required essentially the same skills, but involved different models of furniture and different demands for the conversions and judgments about real furniture. For example, at the fourth grade, the first item combined measurement with students' judgment about going around the bend, and so is not directly comparable with the eighth-grade item. The fourth graders also were not asked to find a general rule. Consequently, comparisons cannot be made between performance on items at the two grade levels. The fourth-grade version of the task, together with sample student responses and criteria for fully-correct responses, is shown in Figure 1.18.

Eighth-grade students found the procedural items involving measurement and scale conversion relatively easy (Table 1.21, Item 1 – average percentage score: 84%; Item 2 – average percentage score: 69%). They also had little difficulty in relating models to the real world (Item 3 – average percentage score: 66%) or in identifying which of two pieces of furniture would go "around the bend" (Item 4 – average percentage score: 69%). Drawing models to scale, conjecturing about which real-life pieces of furniture they might represent, and deciding whether they would go around the bend (Item 5) were all more difficult, with average percentage scores in the 40s and 50s. Finding a general rule for predicting from the length and width of a piece of furniture whether or not it would go around the bend proved extremely challenging for almost all students.

Fourth-grade students were more successful in measuring models and in deciding whether they would go around the bend (Table 1.22, Items 1 and 4 – average percentage scores: 57% and 54%, respectively) than in converting from centimeters to meters (Item 2 – average percentage score: 32%) or making models to scale (Item 3 – average percentage score: 33%).

# FIGURE 1.17 - AROUND THE BEND FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH GRADE

## INTRODUCTION TO TASK

### AROUND THE BEND

**At this station you should have:**

Two rectangles of white card, A and B, which are models of pieces of furniture
1 cm squared graph paper to make different rectangles to be models of other pieces of furniture
Scissors
A 30 cm ruler
Plastic bag and labels
Paper clips
A model representing a corridor in an apartment

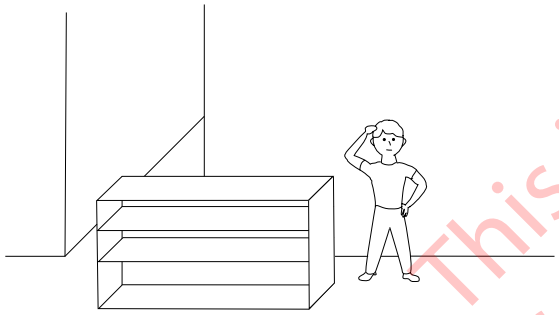
**Your task:**

Find out what sizes of furniture can be moved around the bend in the corridor.

**Read this before answering the questions:**

Ray is to move into an apartment which has the main rooms around a bend in the corridor leading from the front door.

What sizes of furniture will go around the bend in the corridor?

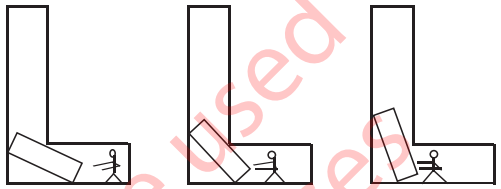


Ray wants to get some large pieces of furniture around the bend the right way up. He does not want to turn the the pieces of furniture on their sides. He uses the models of the corridor and furniture to find out which pieces of furniture will go around the bend.



## ITEMS 1, 2, 3, AND 4

Here are some pictures (not to scale) showing what could happen.



The rectangles representing furniture and the model of the corridor in Ray's apartment are drawn to scale. *Scale: 4 cm represents 1 m.*

1. Measure the lengths and widths of the two models of pieces of furniture in cm.
   A is 8cm cm long and 4cm cm wide.
   B is 4cm cm long and 2cm cm wide.
2. What are the lengths and widths of the two pieces of furniture in meters?
   A is 2m m long and 1m m wide.
   B is 1m m long and ½m m wide.
3. Here is a list of furniture:

   single bed (circled) coffee table (circled) 3-seater couch armchair cot

   double bed dining table 2-seater couch sideboard

   Judging from their sizes:
   What piece of furniture is A most likely to be? Single bed
   What piece of furniture is B most likely to be? coffee table
4. Which piece(s) of furniture (A or B or both) will go around the bend in Ray's apartment and which will not?

piece A will not go around the bend.
piece B will go around the bend.

**Please turn the page.**

## ITEMS 5 AND 6

5. Use the graph paper to make other models of pieces of furniture to the sizes listed in the table below. The sizes are all given in meters.

   In the second column of the table suggest what the furniture could be.

   In the third column find out if the piece of furniture will go around the bend, and check the correct answer.

| | Furniture Size Length (m) | Width (m) | What Furniture could be: | Goes around the bend? Yes, easily | Yes, just | No |
|---|---|---|---|---|---|---|
| C | 0.5 | 0.5 | bedside table | ✓ | | |
| D | 1.5 | 0.5 | 2 seater couch | ✓ | | |
| E | 2 | 0.5 | 3 seater couch | | ✓ | |
| F | 1 | 1 | dining table | | ✓ | |
| G | 1.5 | 1 | double bed | | | ✓ |
| H | 2 | 1 | king size bed | | | ✓ |

6. Whether or not a piece of furniture goes around the bend of Ray's corridor depends on its length and width. Look at the results you have for all the pieces of furniture A, B, C, D, E, F, G and H.

   • Try to find a rule for working out from their lengths and widths whether or not a piece of furniture goes around the bend.

If the width is half as long as the length it will not go around the bend. But it will if the width & length are the same or if the width is less. It will

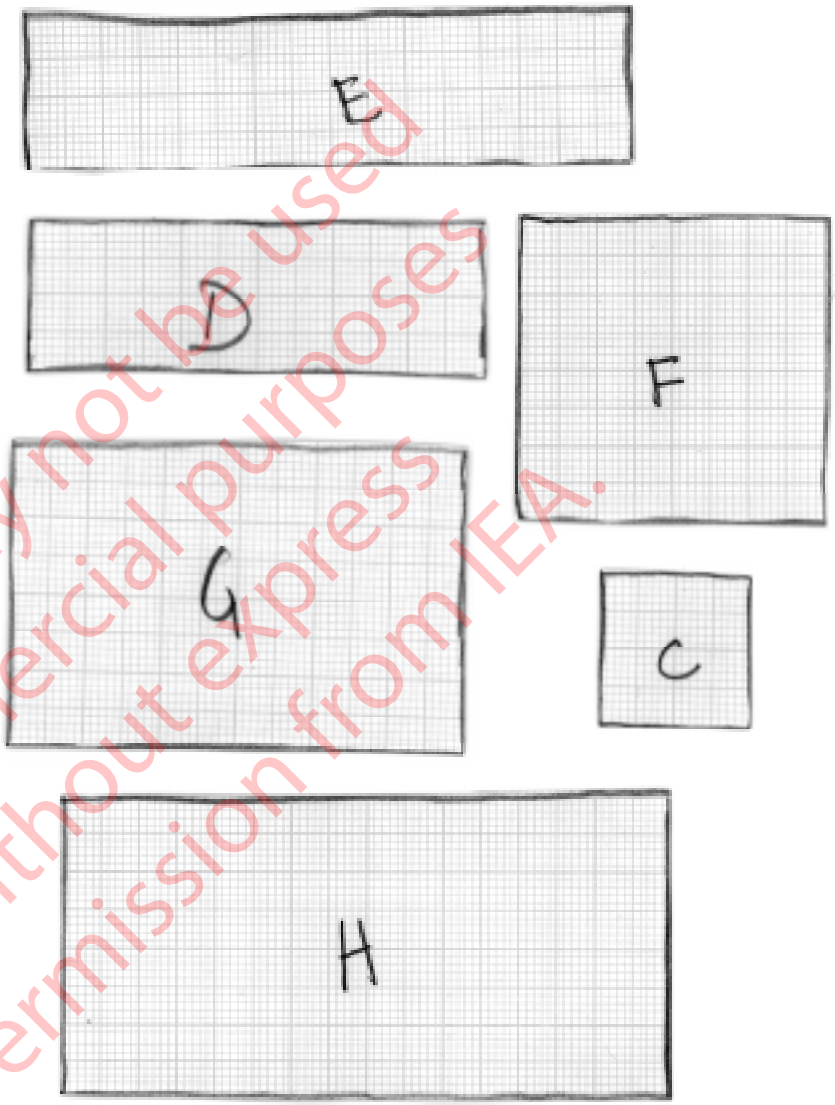
**PUT THE PIECES OF FURNITURE YOU MADE IN THE PLASTIC BAG AND PUT YOUR NAME ON THE LABEL.**

**FASTEN THE BAG TO THIS PAGE WITH A PAPER CLIP.**

**LEAVE THE MODELS A AND B AT THE STATION.**



## ITEM 5 RESPONSE




Shown at actual size

# FIG. 1.17 (CONT.) AROUND THE BEND – EIGHTH GRADE

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Measure lengths and widths of two furniture models.** Length and width measured correctly (in cm) for both pieces (A = 8 cm x 4 cm; B = 4 cm x 2 cm).
*Total Possible Points: 2*

**Item 2 - Convert cm into meters using scale.** Computes conversion of length and width accurately. (A = 2 m x 1 m; B = 1 m x 0.5 m)
*Total Possible Points: 2*

**Item 3 - Relate models to real-world furniture.** Judgments are reasonable for both pieces.
*Total Possible Points: 2*

**Item 4 - Solve problem: which piece(s) of furniture will go around the bend.** i) Response is consistent with measurements. ii) Response is correct (A will not; B will).
*Total Possible Points: 2*

**Item 5 - Draw and make predictions about six models.**
Three aspects of responses were scored separately.

> **Draw or cut models to scale.** i) Correctly applies scale. ii) Computations and drawings are accurate for all 6 pieces (C = 2 cm x 2 cm; D = 6 cm x 2 cm; E = 8 cm x 2 cm; F = 4 cm x 4 cm; G = 6 cm x 4 cm; H = 8 cm x 4 cm).
> *Total Possible Points: 3*
>
> **Relate models to real-world furniture.** Judgments are reasonable for all 6 pieces.
> *Total Possible Points: 2*
>
> **Solve problem: which piece(s) of furniture will go around the bend.** Judges all six pieces of furniture correctly, based on drawings (C and D – Easily; E and F – Just; G and H – No).
> *Total Possible Points: 3*

**Item 6 - Find a general rule for whether furniture will or will not go around the bend.** Includes the correct relationship between length and width based on the corridor dimensions and scale: i.e., furniture will go around the bend if (1/2 x length + width) ≤ 1.5 m.
*Total Possible Points: 3*

# FIGURE 1.18 - AROUND THE BEND ITEMS AND SCORING CRITERIA – FOURTH GRADE



## AROUND THE BEND

**At this station you should have:**

Five rectangles of white card which are models of pieces of furniture: a single bed, a coffee table, a dining table, a sideboard, a bookcase
1 cm squared graph paper to make different rectangles to be models of other pieces of furniture
Scissors
A 30 cm ruler
Plastic bag and label
Paper clips
A model of a corridor in an apartment

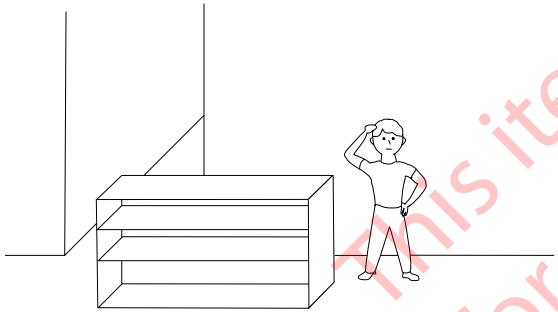
**Your task:**

Find out which pieces of furniture can be moved around the bend in the corridor.

**Read this before answering the questions:**

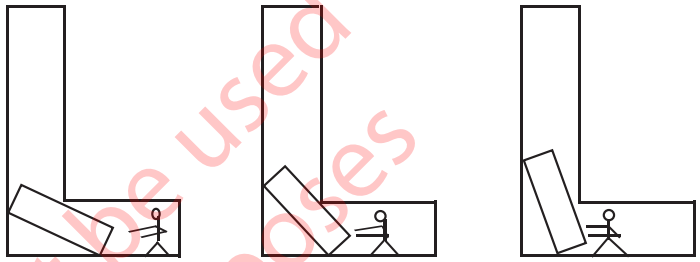
Ray is to move into an apartment which has the main rooms around a bend in the corridor leading from the front door.

What sizes of furniture will go around the bend in the corridor?



Ray wants to get some large pieces of furniture around the bend the right way up. He does not want to turn the pieces of furniture on their sides. He uses the models of the corridor and furniture to find out which pieces of furniture will go around the bend.

Here are some pictures of the corridor each with a piece of furniture showing what could happen.



1. Measure the length and width of the model furniture and find which ones will go around the bend in Ray's corridor. Write down what you find in the table below. Place a checkmark in the correct column to indicate whether or not the furniture goes around the bend.

| Model Furniture | Length cm | Width cm | Goes Round the Bend | | |
|---|---|---|---|---|---|
| | | | Yes easily | Yes barely | No |
| A. Bookcase | | | | | |
| B. Dining Table | | | | | |
| C. Single Bed | | | | | |
| D. Sideboard | | | | | |
| E. Coffee table | | | | | |

The models of pieces of furniture and corridor are made to scale: 4 cm on the model represents 1 m on the real furniture.

2. What is the real size of the bed and the bookcase?

The bed is _____m long and _____m wide.

The bookcase is _____m long and _____m wide.

**Please turn the page.**

# FIGURE 1.18 (CONT.) AROUND THE BEND – FOURTH GRADE

3. Ray wants to buy a coffee table measuring 1 m (length) by 1 m (width) and a double bed measuring 2 m (length) by 1 1/2 m (width).
   - Use the graph paper to cut out models of these pieces of furniture to scale size.

     *Remember the scale: 4 cm on the model represents 1 m on real furniture.*

4. Draw a circle around the correct words:

   The coffee table (**will** / **will not**) go around the bend.

   The double bed (**will** / **will not**) go around the bend.
   - Label the two pieces of furniture "coffee table" and "double bed."

## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - For all 5 pieces: measure furniture models and decide whether they will go around the bend.** i) Length and width measured correctly ( A = 4 cm x 2 cm; B = 6 cm x 6 cm; C = 8 cm x 4 cm; D = 8 cm x 2 cm; E = 6 cm x 4 cm). ii) Judgments about going around the bend are correct (A and E – Easily; D – Barely; B and C – No).
*Total Possible Points: 2*

**Item 2 - Convert cm into meters using scale.** Computes conversion of length and width correctly for both pieces. (Bed = 2 m x 1 m; Bookcase = 1 m x 0.5 m)
*Total Possible Points: 2*

**Item 3 - Cut furniture models to scale.** Both models are drawn or cut accurately (± 3mm). (Coffee table = 4 cm x 4 cm; Double bed = 8 cm x 6 cm)
*Total Possible Points: 2*

**Item 4 - Solve problem: decide whether furniture will or will not go around the bend.** Judges both pieces correctly (Coffee table will just go around; double bed will not).
*Total Possible Points: 2*

# Around the Bend Task: Average Percentage Score on Items - Eighth Grade* Table 1.21

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Item 1 Measure Models A and B | Item 2 Convert Using Scale | Item 3 Relate A and B to Real Furniture | Item 4 Solve Problem With A and B | Item 5 Six Models | | | Item 6 Find General Rule |
| | | | | | | Draw Models to Scale | Relate Models to Real Furniture | Solve Problem with Models | |
| | | 2 Points | 2 Points | 2 Points | 2 Points | 3 Points | 2 Points | 3 Points | 3 Points |
| Sweden | 65 (1.9) | 89 (2.1) | 95 (2.3) | 81 (3.4) | 46 (4.4) | 70 (4.6) | 57 (2.8) | 73 (2.7) | 12 (2.3) |
| Singapore | 63 (1.5) | 94 (1.6) | 82 (3.8) | 76 (2.9) | 89 (2.1) | 66 (4.6) | 33 (1.7) | 64 (2.5) | 2 (0.9) |
| Norway | 62 (1.3) | 96 (1.4) | 80 (2.3) | 67 (2.5) | 82 (3.4) | 54 (3.8) | 48 (2.4) | 63 (2.5) | 7 (0.9) |
| New Zealand | 60 (1.4) | 93 (1.0) | 74 (2.8) | 75 (2.5) | 78 (2.5) | 52 (3.6) | 44 (1.6) | 61 (1.8) | 3 (0.9) |
| Czech Republic | 58 (1.5) | 95 (1.2) | 83 (2.8) | 61 (3.1) | 79 (3.7) | 51 (3.4) | 44 (2.7) | 51 (2.5) | 4 (1.5) |
| † Scotland | 58 (2.1) | 95 (1.8) | 78 (3.7) | 50 (3.2) | 80 (4.2) | 57 (4.8) | 39 (3.2) | 58 (2.9) | 9 (2.6) |
| †1 Switzerland | 54 (2.2) | 81 (4.5) | 80 (4.4) | 47 (3.1) | 64 (3.1) | 58 (5.3) | 31 (2.3) | 63 (3.1) | 9 (1.2) |
| Canada | 53 (2.0) | 82 (3.8) | 67 (2.7) | 63 (3.6) | 68 (4.5) | 48 (3.7) | 42 (2.8) | 56 (3.5) | 1 (0.7) |
| Spain | 53 (1.9) | 90 (2.5) | 59 (4.3) | 80 (3.3) | 72 (3.5) | 31 (3.9) | 46 (3.3) | 44 (3.1) | 4 (1.3) |
| Portugal | 43 (1.8) | 92 (2.6) | 57 (4.4) | 60 (3.7) | 54 (4.3) | 26 (3.9) | 22 (2.9) | 34 (3.3) | 1 (0.4) |
| Cyprus | 42 (1.5) | 67 (3.6) | 41 (4.3) | 60 (2.7) | 69 (4.1) | 28 (4.4) | 31 (3.1) | 37 (2.8) | 0 ~ |
| Iran, Islamic Rep. | 34 (3.2) | 69 (4.8) | 45 (4.8) | 43 (3.0) | 42 (8.0) | 21 (5.3) | 23 (4.6) | 27 (5.1) | 3 (1.6) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | | | | | |
| Australia | 58 (1.8) | 84 (3.4) | 72 (3.7) | 64 (3.2) | 85 (2.5) | 53 (3.8) | 46 (2.6) | 61 (3.1) | 2 (0.7) |
| 2 England | 63 (1.5) | 94 (1.8) | 81 (3.1) | 68 (3.0) | 82 (2.9) | 65 (3.3) | 33 (2.2) | 67 (2.8) | 11 (1.5) |
| Netherlands | 67 (1.9) | 92 (1.9) | 89 (2.6) | 87 (3.5) | 80 (3.0) | 54 (5.1) | 60 (2.9) | 68 (2.7) | 5 (1.3) |
| United States | 48 (1.8) | 68 (3.3) | 53 (4.1) | 66 (3.0) | 62 (3.2) | 33 (3.2) | 45 (2.2) | 52 (2.2) | 3 (1.2) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | | | | | |
| Colombia | 34 (4.4)** | 52 (7.8) | 44 (7.7) | 56 (6.1) | 40 (6.4) | 15 (3.8) | 37 (4.9) | 29 (4.3) | - - |
| 3 Romania | 58 (3.1) | 79 (5.5) | 64 (5.7) | 80 (3.3) | 71 (4.7) | 60 (5.8) | 51 (3.5) | 53 (3.7) | 7 (2.4) |
| Slovenia | 55 (1.9) | 82 (3.4) | 61 (5.0) | 60 (2.5) | 79 (3.7) | 45 (3.9) | 58 (2.9) | 52 (3.2) | 3 (1.0) |
| **International Average** | 54 (0.5) | 84 (0.8) | 69 (0.9) | 66 (0.8) | 69 (0.9) | 47 (1.0) | 42 (0.7) | 53 (0.7) | 5 (0.3) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.

● Percent of total possible points on each item averaged over students.

▼ Average of percentage scores across items; all items weighted equally.

A dash (-) indicates data are not available. Item 6 was not administered in Colombia.

**Overall task average includes an estimated average percentage score of 1% for item 6 imputed based on overall relative country performance and international item difficulty.

† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)

1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.

2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).

3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).

A tilde (~) indicates that standard error could not be estimated.

() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Table 1.22 Around the Bend Task: Average Percentage Score on Items – Fourth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | | |
|---|---|---|---|---|---|
| | | Item 1<br>Measure Models | Item 2<br>Convert Using Scale | Item 3<br>Draw Models to Scale | Item 4<br>Solve Problem With Models |
| | | 2 Points | 2 Points | 2 Points | 2 Points |
| Canada | 49 (2.3) | 65 (2.8) | 36 (3.2) | 33 (3.4) | 62 (2.7) |
| †1 New Zealand | 49 (2.8) | 69 (4.3) | 30 (3.4) | 35 (3.6) | 62 (3.3) |
| Portugal | 38 (3.3) | 63 (4.4) | 32 (4.4) | 23 (4.4) | 32 (4.2) |
| Iran, Islamic Rep. | 28 (3.6) | 42 (5.0) | 18 (3.7) | 23 (4.9) | 27 (3.1) |
| Cyprus | 25 (2.1) | 32 (4.3) | 7 (2.2) | 20 (2.9) | 42 (4.9) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | | |
| Australia | 51 (4.1) | 46 (5.3) | 41 (4.3) | 47 (5.1) | 71 (4.1) |
| Hong Kong | 57 (2.5) | 72 (2.9) | 45 (5.6) | 37 (3.5) | 74 (3.0) |
| United States | 42 (2.9) | 47 (3.9) | 30 (3.7) | 31 (3.6) | 59 (3.3) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | | |
| Slovenia | 57 (2.7) | 78 (2.4) | 46 (4.0) | 44 (3.8) | 61 (3.6) |
| **International Average** | 44 (1.0) | 57 (1.3) | 32 (1.3) | 33 (1.3) | 54 (1.2) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# PACKAGING

The Packaging task involved problem solving in three-dimensional space. Students were supplied with four small plastic balls packed into a square box, some sheets of light cardboard, and an explanation and illustration of a net for the box. With these, and a supply of materials such as a compass, ruler, scissors, adhesive tape, and paper clips, students were to find three other boxes in which the balls could be tightly packed, sketch the boxes, draw a net[4] for each one, and then draw one of the nets to the actual size needed to hold the four balls. The task is intended to measure the students' sense of spatial relations as evident in their ability to visualize different arrangements of objects in boxes, to translate the three-dimensional models first into a two-dimensional sketch, then into the corresponding net, and finally to scale the net to actual size, working from concrete materials rather than by applying a formula to measurements.

The task is the same for both grade levels. The task, together with sample eighth-grade student responses and scoring criteria for fully-correct responses, is shown in Figure 1.19.

As might be expected, eighth-grade students found the task of making and drawing the required boxes moderately difficult (Table 1.23, Item 1 – average percentage score: 53%), but not as difficult as drawing nets (Item 2 – average percentage score: 38%) or drawing a net to scale (Item 3 – average percentage score: 41%). Predictably, the difficulty of the task lay primarily in the net construction, a procedure that may not be emphasized in all curricula. A sample of a net was provided, but in drawing their own nets pupils had to refer continually to their three-dimensional boxes to be sure that all sides were in the right places. Even if they have been taught how, creating a net or projection can be a complex procedure for eighth-grade students. Since eighth-grade students had such difficulty drawing nets, it is not surprising, then, that the fourth-grade students did too. As is evident from Table 1.24, the younger students made some headway with the task of making and drawing boxes (Item 1 – average percentage score: 24%), but found the construction of nets generally beyond them (Items 2 and 3 – average percentage scores: 13% and 16% respectively).

[4] A net is defined here as the two-dimensional pattern that when folded up would yield the three-dimensional object.

# FIGURE 1.19 - PACKAGING FULL-TASK EXAMPLE AND SCORING CRITERIA – EIGHTH AND FOURTH GRADES

## INTRODUCTION TO TASK

### PACKAGING

**At this station you should have:**

4 plastic balls packed in a square shaped box
Blu-tac to stop the balls from rolling around
Some thin card to make a package for the balls
A compass
A 30 cm ruler
Two pieces of thick card to help measure the balls
Scissors
Sellotape
Paperclips

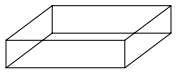
**Your task:**

Design different boxes which will just hold 4 plastic balls.

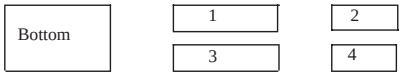
**Read this before answering the questions:**

The following shows what is meant by the net of a box.

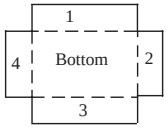
This box has a bottom and 4 sides.



The sides can be cut out separately:




Or the sides can be cut out in one piece and then folded along the dotted lines like this:

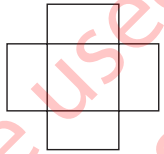



This is a net of a box.

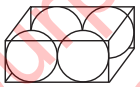


## ITEM 1

This is the shape of a net of a box like the one that holds the 4 balls. It is not drawn to size but if it were, you could fold up the sides and make the box.

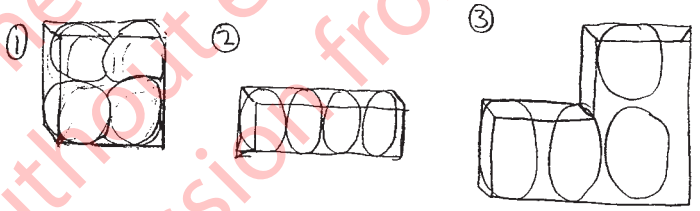


You have been given the box with the four balls just fitting in like this.



Other boxes with different shapes could be made so that the 4 balls would just fit in.

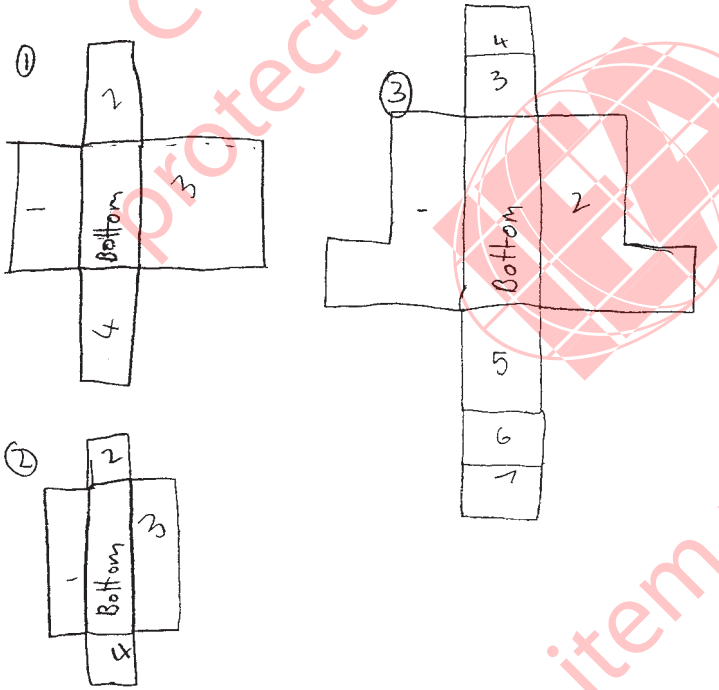
1. Use the balls to find 3 other boxes in which the 4 balls will just fit. Make a drawing of each box with the 4 balls in it.




**Please turn the page.**

## ITEMS 2 AND 3

2. Now make a drawing of the net for each box.



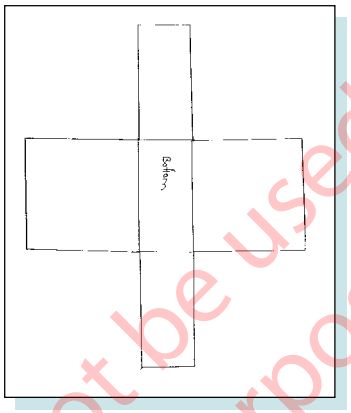

3. Choose ONE of the boxes you have drawn. Take a piece of plain card. On this card draw the net of the design you have chosen. Draw it to the correct size so that if you made the box it would just hold 4 balls.

**ATTACH THE NET TO THIS PAGE WITH A PAPER CLIP.**

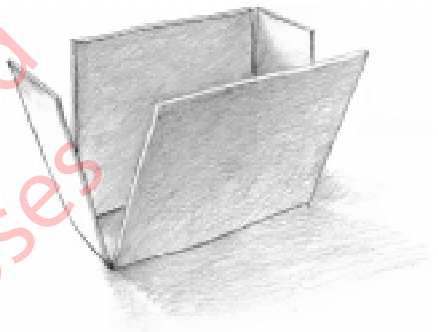
**LEAVE EVERYTHING ELSE AS YOU FOUND IT.**

page 3 TASK M5-P2

## RESPONSE FOR ITEM 3




◀ SHOWN AT 20% OF ORIGINAL SIZE



## CRITERIA FOR FULLY-CORRECT RESPONSE

**Item 1 - Draw three boxes that hold four balls in a "tightly packed" arrangement.** i) Each box describes or shows all four balls. ii) Shows balls in "tightly packed" arrangements. iii) Draws at least two unique arrangements.
*Total Possible Points: 2*

**Item 2 - Draw net for each box.** i) Nets drawn are consistent with at least two of the ball arrangements. ii) Nets clearly show correct shape of base of box and side flaps required to constrain the balls in "tightly packed" arrangements. iii) Nets show side flaps and base of box in correct proportions (not necessarily in actual size).
*Total Possible Points: 2*

**Item 3 - Construct net to scale.** Constructs or draws a net for a box with the following requirements: i) Net is consistent with one of the previous nets drawn. ii) Is constructed out of a single piece of cardboard or pieces are taped together and spread out into a net. iii) Includes base and side flaps that will constrain the balls in the "tightly packed" arrangement when folded up into a box. iv) Dimensions of base and sideflaps are within 4 mm of actual size required to hold the 4 balls.
*Total Possible Points: 2*

# Table 1.23 Packaging Task: Average Percentage Score on Items – Eighth Grade*

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | |
|---|---|---|---|---|
| | | Item 1 Draw Boxes | Item 2 Draw Nets | Item 3 Construct Net to Scale |
| | | 2 Points | 2 Points | 2 Points |
| Singapore | 65 (2.4) | 87 (2.7) | 55 (3.8) | 51 (3.6) |
| Norway | 59 (2.4) | 78 (2.8) | 48 (2.8) | 51 (3.7) |
| Canada | 57 (3.2) | 67 (4.5) | 52 (3.7) | 51 (4.2) |
| † Scotland | 51 (3.9) | 59 (4.9) | 41 (5.1) | 54 (4.0) |
| †1 Switzerland | 47 (3.3) | 50 (4.8) | 56 (3.8) | 35 (4.4) |
| Sweden | 47 (2.3) | 68 (4.2) | 32 (2.6) | 40 (3.7) |
| New Zealand | 44 (2.5) | 59 (3.5) | 38 (3.2) | 34 (2.8) |
| Czech Republic | 43 (4.6) | 53 (5.4) | 39 (4.1) | 38 (5.3) |
| Iran, Islamic Rep. | 43 (5.0) | 39 (7.0) | 23 (4.4) | 67 (5.1) |
| Portugal | 31 (3.2) | 35 (4.6) | 26 (3.3) | 31 (3.8) |
| Spain | 28 (2.3) | 28 (3.5) | 18 (2.6) | 40 (3.5) |
| Cyprus | 14 (2.1) | 12 (3.0) | 10 (2.2) | 19 (3.8) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | |
| Australia | 55 (2.8) | 70 (4.2) | 57 (3.2) | 38 (3.7) |
| 2 England | 53 (2.5) | 72 (3.2) | 44 (2.8) | 45 (3.3) |
| Netherlands | 53 (2.9) | 64 (3.7) | 52 (3.0) | 43 (4.1) |
| United States | 28 (2.5) | 41 (3.3) | 27 (3.3) | 17 (2.4) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | |
| Colombia | 20 (3.0) | 25 (5.0) | 10 (2.4) | 26 (3.7) |
| 3 Romania | 51 (4.1) | 48 (4.9) | 45 (5.5) | 59 (6.6) |
| Slovenia | 45 (3.8) | 48 (3.9) | 41 (4.0) | 47 (5.4) |
| **International Average** | 44 (0.7) | 53 (1.0) | 38 (0.8) | 41 (1.0) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Eighth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 National Desired Population does not cover all of International Desired Population (see Table A.2) - German-speaking cantons only.
2 National Defined Population covers less than 90 percent of National Desired Population for the main assessment (see Table A.2).
3 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.2).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

# Packaging Task: Average Percentage Score on Items – Fourth Grade* Table 1.24

| Country | Overall Task Average▼ | Average Percentage Scores on Items● | | |
|---|---|---|---|---|
| | | Item 1 Draw Boxes | Item 2 Draw Nets | Item 3 Construct Net to Scale |
| | | 2 Points | 2 Points | 2 Points |
| Iran, Islamic Rep. | 34 (5.2) | 28 (6.2) | 24 (4.7) | 49 (6.0) |
| Canada | 27 (2.2) | 38 (3.1) | 23 (2.4) | 21 (2.4) |
| †1 New Zealand | 14 (2.2) | 22 (3.1) | 10 (2.1) | 10 (2.4) |
| Portugal | 8 (1.8) | 11 (3.0) | 5 (1.7) | 7 (2.5) |
| Cyprus | 4 (1.3) | 7 (2.7) | 2 (1.2) | 2 (1.5) |
| ***Countries Not Satisfying Guidelines for Sample Participation Rates (See Appendix A for Details):*** | | | | |
| Australia | 24 (2.0) | 39 (3.8) | 20 (3.1) | 12 (2.3) |
| Hong Kong | 15 (2.4) | 14 (2.4) | 11 (2.6) | 20 (6.9) |
| United States | 13 (1.7) | 20 (2.2) | 9 (2.0) | 10 (2.1) |
| ***Countries Not Meeting Age/Grade Specifications (See Appendix A for Details):*** | | | | |
| Slovenia | 18 (2.4) | 32 (4.2) | 13 (2.1) | 9 (2.7) |
| **International Average** | 17 (0.9) | 24 (1.2) | 13 (0.9) | 16 (1.2) |

SOURCE: IEA Third International Mathematics and Science Study (TIMSS), 1994-95.

* Fourth grade in most countries; see Table 2 for information about the grades tested in each country.
● Percent of total possible points on each item averaged over students.
▼ Average of percentage scores across items; all items weighted equally.
† Met guidelines for sample participation rates only after replacement schools were included (see Appendix A for details)
1 School-level exclusions for performance assessment exceed 25% of the National Desired Population (see Table A.3).
() Standard errors appear in parentheses. Because results are rounded to the nearest whole number, some totals may appear inconsistent.

## SUMMARY

It is clear from the results presented in this chapter that students generally performed well on procedural tasks involving measurement, use of equipment, and routine problem solving, although naturally the level of success in these areas varied with the task context, familiarity, and degree of difficulty. However, both middle- and primary-school students often had serious difficulty providing descriptions of procedures or trends, and especially in explaining findings and deriving general rules for summarizing results. It is probable that describing and explaining knowledge is inherently more difficult than simply knowing something or applying that knowledge. However, most items requiring explanations in the TIMSS performance assessment were designed to elicit conceptual knowledge wherever present, so some of the difficulty with these items may be due to cross-country variation in curricular emphasis. Pedagogical approach could also be a factor, of course, since in some classrooms students are routinely required to justify their answers and explain their thinking, rather than simply supplying right or wrong answers.