New Zealand Year 5 students’ strengths and weaknesses in science items from the Trends in International Mathematics and Science Study (TIMSS) 2006/07

Introduction

Along with children from almost 60 countries, New Zealand’s Year 5 students took part in the 2006/07 cycle of the Trends in International Mathematics and Science Study (TIMSS 2006/07). This study measures trends in mathematics and science achievement in Years 5 and 9 and identifies effective instructional practices from around the world. After every cycle of TIMSS some of the test questions are released to the public, while some are kept confidential to help measure trends from one cycle to the next.

This booklet contains a selection of TIMSS 2006/07 test questions from the three science content domains. We have included examples of questions where New Zealand Year 5 students did better than the international average and examples where they did worse. For those questions where New Zealand students struggled, we have suggested some resources to use in the classroom for teaching the topics these questions relate to. This booklet is intended as a resource for Year 5 science teachers.

The TIMSS content and cognitive domains

The assessment in TIMSS is organised around a content domain and a cognitive domain. The content domain for science has three areas: life science, physical science, and earth science. The life science content area is similar to the Living World strand in the New Zealand Science Curriculum, and the earth science area is similar to the Planet Earth and Beyond strand. The physical science area encompasses both the Material World and Physical World strands of the New Zealand Curriculum.

The cognitive domain for science is made up of three areas that describe the thinking processes students must use as they engage with the content: knowing, applying, and reasoning.

In the content domain, New Zealand Year 5 students did better at earth science questions and worse at physical science questions in 2006/07. In the cognitive areas, our students did better at tasks that required them to use their knowledge and worse at questions that required them to apply their knowledge.

Note that the score points were not evenly distributed across all content and cognitive areas. The distribution reflects the content and cognitive emphasis of the curricula of the participating countries. Note also that the content area in which New Zealand Year 5 students showed the greatest strength, earth science, had the least number of questions.
Test curriculum matching analysis

When developing TIMSS 2006/07, every effort was made to ensure the widest possible coverage of the mathematics and science curriculum in each country. However, inevitably the TIMSS 2006/07 tests were not a perfect match for every curriculum, and so some items fell outside the scope of what the children had learned in class. To address this issue, each country was asked to indicate which items on the tests, if any, were inappropriate for their curriculum. Those items in which New Zealand students did worse than the international average and were judged to be a mismatch for the New Zealand curriculum have not been included in this booklet.

Learning activities in science lessons

In terms of content, the Classroom Context: The Classroom Context for Year 5 Students’ Mathematics and Science Achievement in 2006\(^1\) showed that the most common activities in science lessons, according to teachers, were getting students to give explanations about something they are studying (57% of students were in classes where this was reported to happen in at least half the lessons) and having students relate what they are learning in science to their daily lives (52%). Fewer teachers reported that they asked students to memorise facts and principles (5%) or watch the teacher do a science experiment (5%). In contrast, one of the most common activities reported by students was memorising science facts (60%), along with reading books about science (59%).

Getting students to give explanations about something they are studying and having students relate what they are learning in science to their daily lives were also the two most common activities reported by teachers across most of the English-speaking and high-performing countries. One exception was Chinese Taipei, a high performing country, where doing experiments or investigations was the most common activity reported by teachers.

Interestingly, none of the statements about common activities from students and teachers showed a clear link with achievement. This may be because it is not so much the doing of activities as how they are done and what is learnt during the activity that is important. For example, if a class reads a book about a science topic that confirms and elaborates on work already done in class, it is likely to be a more valuable learning activity than if the book is read in isolation.

How is the information in this booklet presented?

Each item in the three science contents areas gives the question, the content and cognitive domain it relates to, the expected answer (and in some cases typical wrong answers), and a table with a selection of countries’ results for comparison. This table shows the percentage of students who correctly answered the question and achieved the maximum number of points.

Further information about TIMSS

Further information about TIMSS 2006/07, including the full set of released items, can be found at: www.educationcounts.govt.nz/publications/numeracy/timss_200607

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\(^1\) See Caygill, Lang, & Cowles, 2010.
SCIENCE CONTENT AREA: Physical science

Physical science was the content area in which our students did worse overall than the other science content areas, and it encompassed 64 of the 174 questions (67 of 194 total score points). The percentage correct on physical science items ranged from a high of 92% (choosing the hottest temperature on a range of thermometers – international average 90%) to a low of 14% (labelling the freezing point of water on a thermometer – international average 25%).

Two examples of physical science items are presented here. The first is an example of an item of medium difficulty that New Zealand students did relatively well on (Uses of ice). The second is another item of medium difficulty, but New Zealand students did relatively poorly on this one (Water disappearing from a dish).

S03_05A: 11% above the international average

<table>
<thead>
<tr>
<th>Item label:</th>
<th>Content domain:</th>
<th>Cognitive domain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses of ice</td>
<td>Physical science</td>
<td>Knowing</td>
</tr>
</tbody>
</table>

Ice and liquid are different forms of water. Each form is used in different ways. Write down one way that water is used by humans in each of these forms.

Ice:

Liquid:

Fully correct response: Names a correct use of ice.

Examples:
Cooling/freezing, adding to drinks, preserving food, treating injuries/burns, etc

OR other correct.

Examples:
Water is ice but a lot colder.
You can melt it.
Ice is cold, solid, it melts, etc.
When you put water into the freezer it becomes ice.
New Zealand Year 5 students’ strengths and weaknesses in science items from the Trends in International Mathematics and Science Study (TIMSS) 2006/07

<table>
<thead>
<tr>
<th>Country</th>
<th>Percent full credit (weighted)</th>
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<th>Percent full credit (weighted)</th>
</tr>
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<td>Scotland</td>
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<tr>
<td>Singapore</td>
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<td>New Zealand</td>
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</tr>
<tr>
<td>United States</td>
<td>77</td>
<td>International average</td>
<td>55</td>
</tr>
</tbody>
</table>

15.8% of New Zealand students and 9.9% of students internationally who responded to this question incorrectly wrote an answer that referred only to a property of ice, with no specific use provided.
S02_10: 17% below international average

<table>
<thead>
<tr>
<th>Item label:</th>
<th>Content domain:</th>
<th>Cognitive domain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water disappearing from a dish</td>
<td>Physical science</td>
<td>Applying</td>
</tr>
</tbody>
</table>

Grace's teacher places a dish of water on a sunny windowsill. When Grace looks into the dish at the end of the day, the water has disappeared. Explain why the water has disappeared.

**Fully correct response:** Refers specifically to evaporation and/or water vapour forming.

*Examples:*
- The water evaporates into water vapour.
- The sun made the water evaporate.
- Because the heat made it evaporated.
- The water evaporated.
- The water has become water vapour.
- The water became a gas.

**OR other correct**

*Examples:*
- The water absorbs into the sky.
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<tr>
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</thead>
<tbody>
<tr>
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<td>Japan</td>
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<td>Kazakhstan</td>
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<td>Russian Federation</td>
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</tr>
<tr>
<td>England</td>
<td>65</td>
<td>New Zealand</td>
<td>33</td>
</tr>
</tbody>
</table>

There was no sub-coding of the incorrect answers for this question.

Resources

Here are some worksheets about evaporation:
  (this page is the same as the one above, except for the last question)

Note: To use the Assessment Resource Bank resources, you need to have a user name and log-in. You can register and receive these by entering your details on the link below:

Here are some ideas for evaporation activities:
- [www.teachingideas.co.uk/science/evap.htm](http://www.teachingideas.co.uk/science/evap.htm)

Number 15 in the Building Science Concepts series is aimed at Levels 1–2. It has ideas for constructing knowledge and activities about aspects of the water cycle.
SCIENCE CONTENT AREA: Life science

*Life science* was the content area that had the greatest number of TIMSS science items (75 of the 174 items; 85 score points out of 194). The percentage correct for New Zealand students on *life science* items ranged from a high of 93% (matching animals and their habitats – international average 80%) to a low of 12% (name plant parts and their purposes – international average 19%).

Two examples of *life science* items are presented here. The first is an example of a relatively difficult item that New Zealand did well on (*Life cycle of a moth*). The second is one of greater difficulty that New Zealand students did poorly on (*Bird living and cloud non-living*).

**S02_03: 19% above the international average**

<table>
<thead>
<tr>
<th>Item label:</th>
<th>Content domain:</th>
<th>Cognitive domain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life cycle of a moth</td>
<td>Life science</td>
<td>Knowing</td>
</tr>
</tbody>
</table>

The diagram below shows the life cycle of a moth. Write the name of each stage in the boxes provided. One stage has been completed for you.

![Diagram of life cycle of a moth](image)
Fully correct response: Names three stages correctly:

![Diagram showing the life cycle of a butterfly with stages labeled: egg, caterpillar or larva, chrysalis, chrysalid, pupa, or cocoon.]

Partially correct response: Name one or two stages correctly.

<table>
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<th>Percent full credit (weighted)</th>
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</tr>
<tr>
<td>Hungary</td>
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<td>International average</td>
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</table>

There was no sub-coding of the incorrect answers for this question.
### S04_04: 12% below the international average

<table>
<thead>
<tr>
<th>Item label</th>
<th>Content domain</th>
<th>Cognitive domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bird living and cloud non-living</td>
<td>Life science</td>
<td>Applying</td>
</tr>
</tbody>
</table>

A bird is living and a cloud is non-living.

Give two reasons why a bird is classified as living and a cloud is classified as non-living.

1.  

2.  

**Fully correct response:** Accepted responses refer to:
- Growth/development
- Reproduction
- Respiration
- Intrinsic movement
- Nutrition
- Excretion
- Responding to stimuli

Refrs to two reasons indicated in the list above.

**Examples:**
- A bird can lay eggs and breathes.
- A bird can move on its own. A bird eats.
- A cloud cannot move on its own. Clouds cannot eat.
- A bird fluffs up its feathers. A bird gets rid of its waste.
- A bird can hatch from an egg and a bird can die.

**Partially correct response:** Refers to one accepted reason indicated in the list above.
<table>
<thead>
<tr>
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<th>Percent full credit (weighted)</th>
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<th>Percent full credit (weighted)</th>
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</thead>
<tbody>
<tr>
<td>Singapore</td>
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<td>International average</td>
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<td>Kazakhstan</td>
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<tr>
<td>United States</td>
<td>30</td>
<td>New Zealand</td>
<td>13</td>
</tr>
</tbody>
</table>

There was no sub-coding of the incorrect answers for this question.

**Resources**

Here is a very basic worksheet on similarities and differences between a cat (living) and a chair (non-living):


Here is a page more appropriate to the TIMSS question. It describes what makes a living thing, but also stresses that to be living, something must exhibit all the characteristics, as some non-living things can show one or two characteristics:

▷ [www.saburchill.com/chapters/chap0001.html](http://www.saburchill.com/chapters/chap0001.html)

Here is a lesson plan for introducing students to living versus non-living. It may be a bit basic for Year 5 but it is a good grounding, plus it provides video clips, worksheets, etc. to support learning:

**SCIENCE CONTENT AREA: Earth science**

*Earth science* was the content area with the smallest number of TIMSS science items (36 of 174 items; 42 score points out of 194) but the one in which New Zealand students scored the best out of the three content domains. Percentage correct on *earth science* items ranged from a high of 89% (naming seasons — international average 75%) to a low of 16% (explanation of water and air pressure in an experiment — international average 21%).

Two examples of *earth science* items are presented here. The first is an example of an item of middling difficulty that New Zealand students did comparatively well in (*One way Sun and Moon differ*). The second is a more difficult one in which New Zealand scored just under the international average (*Main reason we see the Moon*).

### S05_08: 18% above the international average

<table>
<thead>
<tr>
<th>Item label:</th>
<th>Content domain:</th>
<th>Cognitive domain:</th>
</tr>
</thead>
<tbody>
<tr>
<td>One way Sun and Moon differ</td>
<td>Earth science</td>
<td>Knowing</td>
</tr>
</tbody>
</table>

![Image](nanx2951357825835384582629174934067918928307164271854434750396402509936757849454110740829479716428049308005659938040923708434913568099879454363954774962792792697356877860673788499039648017630343471992503535142412142634502930578475760535835410920834315514672932503358922291218254320473877891776512000)

*Write down one way that the Sun and the Moon are different from each other.*

| Fully correct response: | Refers to the Sun giving off light or heat and/or the Moon not. |

**Examples:**
- The Sun brings light and the Moon does not.
- Sun is hot, Moon is not.
- The Sun is a big fire ball.
- The Sun shines light. The Moon glows.
- The Moon is cold. The Sun is not.
- The Sun makes its own light but the Moon reflects it.

**OR** refers to differences in visibility (or appearance).

**Examples:**
- Sun is bright, so it’s easier to see during the day.
- Sun is yellow, not blue like Moon.
- Sun is always the same shape but Moon is not.
- The Sun comes up every morning, but the Moon does not.
- They are different colours.
- The Sun doesn’t come out at night.
- The Moon can block the sun, but the Sun cannot block the Moon.

**OR** refers to differences in size, composition or physical/structural features.

**Examples:**
- Sun is a star.
- Moon has craters.
- Sun has lots of gases and Moon is just rock.
- The Sun is bigger.
OR other correct.

**Examples:**
The Moon is closer than the Sun.
The Moon only comes out at night.
You see the Sun in the day and the Moon at night.
One comes out in the day and one comes out at night.

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<td><strong>New Zealand</strong></td>
<td><strong>75</strong></td>
<td><strong>International average</strong></td>
<td><strong>57</strong></td>
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</tbody>
</table>

12.5% of New Zealand students and 15.4% of students internationally who responded to this question incorrectly wrote an answer that refers to the Moon only being visible at night.
S03_08: 1% below the international average

New Zealand students achieved 1% below the international average in this item, but in all of the other released items in this content area our students were often equal to or higher than the international average.

<table>
<thead>
<tr>
<th>Item label: Main reason we see the Moon</th>
<th>Content domain: Earth science</th>
<th>Cognitive domain: Applying</th>
</tr>
</thead>
</table>

What is the main reason we can see the Moon?

A. The Moon reflects light from the Earth.
B. The Moon reflects light from the Sun.
C. The Moon produces its own light.
D. The Moon is larger than stars.

Fully correct response: B

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<td>Chinese Taipei</td>
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<tr>
<td>England</td>
<td>67</td>
<td>New Zealand</td>
<td>45</td>
</tr>
</tbody>
</table>

There was no sub-coding of the incorrect answers for this question.

Resources

This first resource is Number 8 in the Building Science Concepts series. It discusses ideas associated with the Moon and contains related activities (although these might not be as relevant to the TIMSS item). It is aimed at curriculum Levels 3–4 so is possibly at a bit higher level of curriculum than the TIMSS students. Then again, if New Zealand is only 1% lower than the international average, a bit of extension might not be a bad thing!


This next resource has animations of the phases of the Moon as seen from Earth and as seen from space, with some starter questions for discussion. They can also be downloaded. They are aimed across Levels 1–4.

- [www.tki.org.nz/r/science/day_night/dswmedia/moon3_e.php](http://www.tki.org.nz/r/science/day_night/dswmedia/moon3_e.php)
- [www.tki.org.nz/r/science/day_night/dswmedia/moon4_e.php](http://www.tki.org.nz/r/science/day_night/dswmedia/moon4_e.php)

Here is a really good practical lesson plan using items in the classroom as stand-ins for the Moon and the Earth to help show students the phases of the Moon, etc:

- [www.lpi.usra.edu/education/skytellers/moon_phases/activities/fruit.shtml](http://www.lpi.usra.edu/education/skytellers/moon_phases/activities/fruit.shtml)
References
