Chapter 4
The Intellectual Demands of East-Asian Primary Science Curricula

Overall Cognitive Processes and Knowledge Levels Across Six States

Tables 4.1 and 4.2 show our coding of the cognitive processes and levels of knowledge of the intended primary science curricula across all the six East-Asian states respectively. It is to be remembered that some degree of subjectivity is inevitable when coding the intellectual demands, especially with the large number of learning objectives or standards that we selected belonging to the cognitive domain. In total, these amounted to 560 objectives/standards from the six states.

In the cognitive process of Remember, three states (China, Hong Kong, Singapore) garnered high amounts of representation here with about a third of their curriculum (cognitive domain only) inside this category. As to be expected, most of the East-Asian learning objectives were very well represented in Understand; most states had at least a quarter to a third of their objectives located here with the singular exception of Japan. In fact, in the Japanese curriculum nearly every objective was located within Apply, which paralleled the strong national emphasis on applied knowledge of science during classroom teaching and learning. Seen from another angle, this emphasis on hands-on activities in Japan led to the absence of items in Remember, Understand, Evaluate, and Create. Korea too recently had a strong emphasis on learning science through hands-on activities; Apply therefore had 62 % of all objectives located here. Items in Analyze, Evaluate, and Create in the RBT are considered to require higher order thinking skills; it was observed that most states had modest frequencies of items (~ 5 %) in these three categories. Of note, Taiwan had 10 % of their learning objectives in Create, which was the highest figure among the six states followed closely by Hong Kong with 7 %. Only three states—Korea, Japan, Singapore—lacked at least one or more objectives within any of the six cognitive processes in RBT.
In terms of the knowledge dimension, Conceptual occupied the lion’s share of objectives from every state (ranging from 35 to 79 %), a pattern that is to be expected (other than Taiwan). In particular, Korea, Japan, and Singapore were extremely well represented in this category. It is interesting to note that Factual items (other than from China) were not plentiful and ranged from about 16 % to nearly 0 % for Korea and Japan. Procedural knowledge too was well represented in the Taiwanese curriculum; items here occupied nearly half of all learning objectives from this state while the other states had between 20 and 30 % representation in this knowledge group. The category of Metacognitive was very poorly represented in all six states. Again, only three states—Korea, Japan, Singapore—lacked at least one objective within the four knowledge domains in coding of RBT.

It is interesting to note that almost two-thirds of the learning objectives belonged both to Apply and Procedural in the Korean curriculum. This result came from the unique structure of learning objectives, that is, many objectives adopted the form of by/through doing certain scientific process students will achieve certain types of knowledge. In this form, students are engaged in Apply processes and Procedural knowledge. In Japan, the recommended teaching method whereby students had to do something in order to learn scientific ideas was even more stark; 93.5 % of Japanese objectives were in Apply and 74.2 % in Conceptual! We now describe the findings of our codings for each of the six states in turn.

Table 4.1 The overall profile of learning objectives/standards in % from six East-Asian states classified by the cognitive processes in RBT

<table>
<thead>
<tr>
<th>State</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong (n = 57)</td>
<td>31.6</td>
<td>31.6</td>
<td>21.1</td>
<td>5.2</td>
<td>3.5</td>
<td>7.0</td>
</tr>
<tr>
<td>Japan (n = 31)</td>
<td>0</td>
<td>0</td>
<td>93.5</td>
<td>6.5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>China (n = 162)</td>
<td>29.6</td>
<td>38.9</td>
<td>19.8</td>
<td>3.7</td>
<td>3.1</td>
<td>4.9</td>
</tr>
<tr>
<td>Taiwan (n = 114)</td>
<td>16.7</td>
<td>24.6</td>
<td>38.6</td>
<td>5.3</td>
<td>4.3</td>
<td>10.5</td>
</tr>
<tr>
<td>Korea (n = 113)</td>
<td>0</td>
<td>34.5</td>
<td>62.0</td>
<td>0</td>
<td>0</td>
<td>3.5</td>
</tr>
<tr>
<td>Singapore (n = 83)</td>
<td>31.4</td>
<td>32.5</td>
<td>31.4</td>
<td>4.8</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 4.2 The overall profile of learning objectives/standards in % from six East-Asian states classified by the knowledge domains in RBT

<table>
<thead>
<tr>
<th>State</th>
<th>Factual</th>
<th>Conceptual</th>
<th>Procedural</th>
<th>Metacognitive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hong Kong (n = 57)</td>
<td>15.8</td>
<td>49.1</td>
<td>33.3</td>
<td>1.8</td>
</tr>
<tr>
<td>Japan (n = 31)</td>
<td>0</td>
<td>74.2</td>
<td>25.8</td>
<td>0</td>
</tr>
<tr>
<td>China (n = 162)</td>
<td>26.5</td>
<td>54.3</td>
<td>18.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Taiwan (n = 114)</td>
<td>16.7</td>
<td>35.1</td>
<td>47.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Korea (n = 113)</td>
<td>0.9</td>
<td>79.6</td>
<td>19.5</td>
<td>0</td>
</tr>
<tr>
<td>Singapore (n = 83)</td>
<td>16.9</td>
<td>67.5</td>
<td>15.6</td>
<td>0</td>
</tr>
</tbody>
</table>
Hong Kong

General Introduction

Having a high-performing education system, Hong Kong presents many insightful lessons regarding curriculum reforms interacting with larger sociopolitical changes, not just within the discipline of science education (e.g., Kennedy 2005; Marsh and Lee 2014). Primary science (i.e., science and technology education) is part of the General Studies (GS) curriculum in Hong Kong SAR, which combines learning about science, health education, and social studies through inquiry. Published in 2002, GS was fully implemented in 2004 and consists of six strands, namely:

- Health and Living
- People and Environment
- Science and Technology in Everyday Life
- Community and Citizenship
- National Identity and Chinese Culture

Moreover, the aims of GS are the following:

- to provide learning experiences for students to have a better understanding of themselves and the world around them
- to arouse students’ interest in and develop their skills to enquire about themes and issues related to science, technology, and society
- to cultivate positive attitudes and values for healthy personal and social development (CDC 2011, p. iii).

Organized into Key stages 1 (Grades 1–3) and 2 (Grades 4–6), GS occupies 12–15 % of total curriculum time or slightly over 3 hours per week to cover the six GS strands. Because this is an integrated curriculum, we took what we deemed as relevant learning objectives in science, technology, and human health from the first three strands listed above. The list of our choices deemed typical of primary science learning is available upon request. The overarching curriculum framework in Hong Kong consists of three elements: Eight Key Learning Areas (KLA, which comprises the typical subjects), nine generic skills, and various values and attitudes. It should be patently clear by now that curriculum in Hong Kong expresses and is overlaid with various aims, objectives, and goals of which not every one has been described in this chapter. This highly sophisticated conceptualization of what is an educated person ready for life in a globalized world has led Robin Alexander, noted comparative researcher of primary education systems to declare that:

I have to say that this is one of the more complex of the hybrid specifications that I have seen, because although it starts as the familiar two-dimensional grid (key learning areas – or subjects – and generic skills) it actually has six dimensions. This degree of complexity raises the stakes when it comes to implementation, and makes it possible that some
elements, in some schools, will be delivered more as rhetoric than practice, for it is hard to pursue so many objectives simultaneously. (Alexander 2008, p. 149)

Hong Kong teachers are encouraged to contextualize the GS curriculum to address the needs of each school as well as use different approaches and strategies. It comes as no surprise that school-based curriculum development features very large here when teachers are told to devote 80% of teaching time on the core curriculum, while the rest of the time they have the freedom to cater to specific interests and needs of their students. With respect to the teaching of science, attention should be paid to providing many hands-on learning experiences in and out of the classroom. This active learning approach was also to be coupled with the development of scientific thinking and critical reasoning in the subject (CDC 2002). In parallel to the GS curriculum, there are six strands in the science curriculum that are as follows:

- Scientific Investigation—to develop science process skills and understanding of the nature of science
- Life and Living—to develop understanding of scientific concepts and principles related to the living world
- The Material World—to develop understanding of scientific concepts and principles related to the material world
- Energy and Change—to develop understanding of scientific concepts and principles related to energy and change
- The Earth and Beyond—to develop understanding of scientific concepts and principles related to the Earth, Space, and the Universe
- Science, Technology and Society (STS)—to develop understanding of the interconnections between science, technology, and society (CDC 2002, p. 20).

**Overall State Profile of Learning Objectives**

Items in Conceptual alone accounted for half of all learning objectives in Hong Kong (see Table 4.3). The next most frequent items were in the Procedural domain which occupied a third of all items. With respect to processes, both Remember and Understand had 63.2% of all items that was close to the number in the three pairings of Remember-Factual, Understand-Conceptual, and Apply-Procedural (68.4%). Although the pair Conceptual:Understand was supposed to be the most ubiquitous, it just garnered 31.6% of all items in Hong Kong.
It is interesting to note that as children in Hong Kong move up to Key Stage 2, the number of items in Conceptual increased nearly threefold at the expense of items in Procedural, and especially in Factual (Table 4.4). This might reflect a move away from teaching using hands-on learning activities toward learning of abstract conceptual knowledge although there is no way to ascertain this speculation from the learning objectives. For good reasons many policymakers wish not to place too great a burden on younger children on their initial encounters with science. As well, for curricula that adopt a spiral approach, simply counting the changes in the learning objectives might not provide the full picture of the intellectual demands that come with monitoring these numbers across grade levels; not all objectives are indeed the same.

The two Key Stages in Hong Kong are rather similar in terms of their cognitive profiles though again we can observe an increase in Understand, which is expected because of the large increase in Conceptual knowledge demands among items (see Table 4.5).

**Profile of Upper and Lower Primary Learning Objectives**

It is interesting to note that as children in Hong Kong move up to Key Stage 2, the number of items in Conceptual increased nearly threefold at the expense of items in Procedural, and especially in Factual (Table 4.4). This might reflect a move away from teaching using hands-on learning activities toward learning of abstract conceptual knowledge although there is no way to ascertain this speculation from the learning objectives. For good reasons many policymakers wish not to place too great a burden on younger children on their initial encounters with science. As well, for curricula that adopt a spiral approach, simply counting the changes in the learning objectives might not provide the full picture of the intellectual demands that come with monitoring these numbers across grade levels; not all objectives are indeed the same.

The two Key Stages in Hong Kong are rather similar in terms of their cognitive profiles though again we can observe an increase in Understand, which is expected because of the large increase in Conceptual knowledge demands among items (see Table 4.5).

**Table 4.3** Table showing total number of learning objectives \((n = 57)\) from Hong Kong (SAR) classified according to the dimensions of knowledge and cognitive processes in RBT

<table>
<thead>
<tr>
<th>Knowledge Items</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Number of Knowledge Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factual</strong></td>
<td>9 (100)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>9 (15.8)</td>
</tr>
<tr>
<td></td>
<td>(50.0)</td>
<td>(100)</td>
<td></td>
<td>(3.7)</td>
<td>(3.7)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conceptual</strong></td>
<td>8 (29.6)</td>
<td>18 (66.7)</td>
<td>0</td>
<td>1 (3.7)</td>
<td>0</td>
<td>0</td>
<td>27 (49.1)</td>
</tr>
<tr>
<td></td>
<td>(44.4)</td>
<td>(100)</td>
<td></td>
<td>(33.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Procedural</strong></td>
<td>1 (5.0)</td>
<td>0</td>
<td>12 (60.0)</td>
<td>2 (10.0)</td>
<td>1 (5.0)</td>
<td>4 (20.0)</td>
<td>20 (33.3)</td>
</tr>
<tr>
<td></td>
<td>(5.6)</td>
<td>(100)</td>
<td>(66.7)</td>
<td>(50.0)</td>
<td>(50.0)</td>
<td>(100)</td>
<td></td>
</tr>
<tr>
<td><strong>Metacognitive</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (100)</td>
<td>0</td>
<td>1 (1.8)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(5.6)</td>
<td></td>
<td></td>
<td>(50.0)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of Cognitive Items</strong></td>
<td>18 (31.6)</td>
<td>18 (31.6)</td>
<td>12 (21.1)</td>
<td>3 (5.2)</td>
<td>2 (3.5)</td>
<td>4 (7.0)</td>
<td>57</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

**Table 4.4** Number of learning objectives in the knowledge domain from Hong Kong (SAR) sorted according to their grade levels

<table>
<thead>
<tr>
<th>Key stage</th>
<th>Factual</th>
<th>Conceptual</th>
<th>Procedural</th>
<th>Metacognitive</th>
<th>Total ((n = 57))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>8 (32.0)</td>
<td>6 (24.0)</td>
<td>11 (44.0)</td>
<td>0</td>
<td>25 (43.8)</td>
</tr>
<tr>
<td>2.</td>
<td>1 (3.1)</td>
<td>21 (65.7)</td>
<td>9 (28.1)</td>
<td>1 (3.1)</td>
<td>32 (56.2)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
Japan

General Introduction

Education in Japan follows a 6-3-3 pattern starting with six years of primary education and three for lower secondary education thus making a total of nine years of compulsory education. Science lessons begin in the third grade and science is a required subject throughout compulsory education. In elementary schools, science is taught to all students in mixed-ability classes and pupils are not streamed/tracked. Unlike the situation for entry to high schools and universities, there is no entrance examination for public junior high schools.

The Japanese national curriculum—the Courses of Study—has been revised eight times since its implementation in 1947 to keep up with changes in society over the years and the learning needs of each age group. The current Course of Study for Elementary Schools, which includes the primary science curriculum, was announced in March 2008, and fully implemented from April 2011. The subject-specific sections of the Course of Study for Elementary Schools consist of three parts: Overall objectives; Objectives, and contents for each grade or section (objectives, contents and teaching (handling) of the contents), and Syllabus design and guidance for teaching (handling) the contents. In section 4 of the Course of Study for science, it lists the overall objectives of primary science, the objectives and contents for each grade (Grades 3–6), and the syllabus design and suggestions for instruction (handling the contents). Examples of the overall objectives of primary science subject together with some of the specific objectives and content in Grade 3 are shown below:

Overall objectives:
To enable pupils to become familiar with nature and to carry out observations and experiments with their own prospectus, as well as to develop their problem-solving abilities and nurture hearts and minds that are filled with an affection for the natural world, and at the same time, to develop a realistic understanding of natural phenomena, and to foster scientific perspectives and ideas.

### Table 4.5  Number of learning objectives in the cognitive domain from Hong Kong (SAR) sorted according to their grade levels

<table>
<thead>
<tr>
<th>Key stage</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Total (n = 57)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>9 (36.0)</td>
<td>6 (24.0)</td>
<td>6 (24.0)</td>
<td>1 (4.0)</td>
<td>1 (4.0)</td>
<td>2 (8.0)</td>
<td>25 (43.8)</td>
</tr>
<tr>
<td>2.</td>
<td>9 (28.1)</td>
<td>12 (37.5)</td>
<td>6 (18.8)</td>
<td>2 (6.3)</td>
<td>1 (3.0)</td>
<td>2 (6.3)</td>
<td>32 (56.2)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
Grade 3
1. Objectives:
(1) To develop perspectives and ideas about the properties and functions of weight, wind, force of rubber, light, and magnets and electricity through investigation comparing phenomena involving these matters, and through probing the identified problem and making learning material with interest.

(2) To foster an attitude of loving and protecting living things and to develop perspectives and ideas about the relationship between living things and the environment, the relationship between the sun and its effects on conditions on earth, through investigation comparing familiar animals and plants, and sunny and shady spots, as well as through probing the identified problems with interest.

2. Content:
A. Matter/Energy
(1) Object and weight
To develop pupils’ ideas about properties of objects by examining the weights and volumes, using objects such as clay.
  a. The weight of an object remains unchanged even when the shape changes.
  b. Objects with the same volume may differ in weight.

B. Life/the Earth
(1) Insects and plants
To develop pupils’ ideas about growth patterns and body structures by finding and raising familiar insects and plants, and by exploring the processes of their growth and body structure.
  a. Insects grow in accordance with a fixed order of growth, and their body parts consist of the head, thorax, and abdomen.
  b. Plants grow in accordance with a fixed order of growth, and their body parts consist of roots, stems, and leaves. (MEXT 2008a)

The learning objectives from every grade belong to either of two parts—Matter/energy and Life/the Earth—taking into account the characteristics of the learning objects, and the perspectives and ideas developed by the pupils. Objectives relating to Matter/energy in each grade include making things/products since the focus here is on authentic understanding while those in Life/the Earth include developing an attitude of care and protection of living things, and to respect life since this part focuses on nurturing hearts and minds that are filled with an affection for the natural world (MEXT 2008b).

As described in the overall objectives, developing students’ problem-solving abilities is strongly emphasized in the primary science curriculum. Problem-solving in the Japanese primary science most often means a series of steps of scientific inquiry. One example of the process of problem-solving consists of “contact with a natural phenomenon,” “awareness/questions,” “understanding the questions,” “assumption/hypothesis,” “experiment design,” “carrying out the experiment,”
obtaining results,” “discussion,” “conclusion,” and “delivery” (MEXT 2006). As abilities or means of problem-solving, the objectives of each grade specify the prioritized problem-solving abilities of the grade, such as comparing phenomena (Grade 3), relating a change with its contributing factors (Grade 4), controlling conditions when observing/experimenting (Grade 5), and reasoning (Grade 6). These abilities are often viewed as shishitsu noryoku or competencies in science and some subject matter are intentionally arranged in such a way that the content are well-related to the competencies. This would thus show how the particular competencies in science are useful when solving the given problems (Matsubara 2015).

As seen above, there are only two objectives for Grade 3. Likewise, Grades 4, 5, and 6 each have two objectives, making up only eight objectives for Japan’s primary science curriculum. Each objective contains a sizeable amount of information, covering about half of the learning content for the grade. Compared to the learning objectives of five other states, one might say Japan’s objectives for each grade tend to be general and broad. Considering such particular circumstances, this study will be dealing with the content of each grade rather than the objectives of each grade in the context of the Japanese primary science curriculum and will be using the descriptions of the content in the analysis of objectives. In this way, we believe we will be able to compare the objectives among the six states with better validity. Two examples of the content of Grade 3 are given above. The descriptions of the content, such as “to develop pupils’ ideas about the properties of objects by examining weights and volumes using objects such as clay,” are considered to be objectives suitable for analysis.

The content in each grade basically consists of the following points in the following order, to enable pupils to carry out problem-solving activities with learning objects and to achieve the objectives of each grade (MEXT 2008b).

(1) First, the learning object and activities are specified, such as “using objects such as clay” (Another example may be “by finding and raising familiar insects and plants”).

(2) Second, the perspective of learning is specified, such as “by examining the weights and volume” (Another example may be “by exploring the processes of their growth and body structure”).

(3) Then, the expected ideas to be developed by pupils in the process of their learning or as a result of their learning are specified, such as “develop pupils’ ideas about the properties of objects” (Another example may be “develop pupils’ ideas about growth patterns and body structures”).

(4) Next, descriptions under (a) and (b) show the content of detailed ideas about the learning object, which are expected to be developed by pupils as a result of their learning.

(5) In order to ensure pupils’ proactive problem-solving activities, the content is chosen and arranged in a way that pupils can work on natural phenomena and develop scientific perspectives and ideas.
**Overall National Profile of Learning Objectives**

As we have found from our coding in Table 4.6, there is a distinctive pattern in the learning objectives from Japan that reflects the wording of the official curriculum document to foreground doing activities in order to learn scientific concepts. With such a strong emphasis on the former, it was found that 93.5% of all items could be categorized in Apply, which implied much hands-on learning of science. This figure as previously mentioned was the highest of any domain (cognitive or knowledge) among all six states that were compared in this book. As well, we found a complete absence of items in Understand or Remember, which normally would have garnered a large percentage of items. None of the typical pairings of Factual-Remember or Conceptual-Understand were present; Procedural-Apply, however, had 25.8% of all objectives in Japan. Most of the objectives were found in the Conceptual: Apply (67.7%) pairing followed by Procedural-Apply that was less than half of the former. Compared to other states, there were no items in Evaluate and Create either, but this must be appreciated in the light that the Japanese curriculum was the state here with the fewest number of learning objectives.

**Profile of Upper and Lower Primary Learning Objectives**

Both Tables 4.7 and 4.8 follow closely the overall national profile, but with relatively few items it is hard to make definitive conclusions about the intellectual demands of primary science as children grow older in Japan.

**Table 4.6** Table showing total number of learning objectives \((n = 31)\) from Japan classified according to the dimensions of knowledge and cognitive processes in RBT

<table>
<thead>
<tr>
<th></th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Number of knowledge items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Conceptual</td>
<td>0</td>
<td>0</td>
<td>21 (91.3) (72.4)</td>
<td>2 (8.7) (100)</td>
<td>0</td>
<td>0</td>
<td>23 (74.2)</td>
</tr>
<tr>
<td>Procedural</td>
<td>0</td>
<td>0</td>
<td>8 (100) (27.6)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8 (25.8)</td>
</tr>
<tr>
<td>Metacognitive</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Number of cognitive items</td>
<td>0</td>
<td>0</td>
<td>29 (93.5)</td>
<td>2 (6.5)</td>
<td>0</td>
<td>0</td>
<td>31</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
Table 4.7  Number of learning objectives in the knowledge domain from Japan sorted according to their grade levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Factual</th>
<th>Conceptual</th>
<th>Procedural</th>
<th>Metacognitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–4</td>
<td>0</td>
<td>12 (80.0)</td>
<td>3 (20.0)</td>
<td>0</td>
<td>15 (48.4)</td>
</tr>
<tr>
<td>5–6</td>
<td>0</td>
<td>11 (68.8)</td>
<td>5 (31.2)</td>
<td>0</td>
<td>16 (51.6)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

Table 4.8  Number of learning objectives in the cognitive domain from Japan sorted according to their grade levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–4</td>
<td>0</td>
<td>0</td>
<td>15 (100)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>15 (48.4)</td>
</tr>
<tr>
<td>5–6</td>
<td>0</td>
<td>0</td>
<td>14 (87.5)</td>
<td>2 (12.5)</td>
<td>0</td>
<td>0</td>
<td>16 (51.6)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

The People’s Republic of China

General Introduction

In the national curriculum for elementary education, there are several subject-based courses such as Chinese literature, mathematics, foreign language (English), ethics and society (ethics and life), science, physical education, music, and arts. Science in primary schools is taught from Grades 3 to 6 and teaching hours vary from place to place, but it is taught at least two hours per week and by teachers who are content generalists. The present primary science curriculum document—Full-time Compulsory Science Curriculum Standards (Grade 3–6)—was officially released by the Ministry of Education in mainland China for implementation in 2001. Realizing that science education had formerly paid too much emphasis to the acquisition of basic science knowledge and had largely ignored students’ interests or needs (Ding 2001), Chinese science educators and curriculum developers now wanted to cultivate students’ scientific literacy through inquiry and scientific processes. The latter, as well as the nurturing of scientific attitudes became key goals of science teaching as described below in the curriculum:

- Students know basic scientific knowledge related to common phenomena in daily life and are able to apply this knowledge in everyday life situations, and gradually develop scientific habits and lifestyles
- Students understand the processes and methods of scientific inquiry, attempt to use them in inquiry activities, and gradually learn to think and solve problems in scientific ways
Students maintain and develop curiosity about the world and thirst for knowledge, cultivate scientific attitudes (including bold imagination, respect for evidence, and innovation), and emotions (including the love of science and homeland). Students are willing to get close to and appreciate nature, cherish life, participate in the protection of natural resources and environment, and be aware of new developments in technology.

Unlike the previous curriculum, knowledge and practical skills no longer formed the main focus; memorization, concept-based tests, and technique-based, hands-on skills of science teaching were to be replaced by evidence-based inquiry as the main teaching approach. The emphasis on scientific inquiry and attitudes was also evident in how the learning standards were worded. For instance, some inquiry skills were distinctly stated as learning objectives such as “students know that in scientific inquiry, asking and answering questions and their outcomes have to be compared with one’s own finding as well as conclusions from science and students know that different questions need different methods of inquiry.” In all, these were very bold and ambitious goals that subscribed to an underlying constructivist philosophy of learning that was a major and genuine reform as commentators have noted (OECD 2011). However, as seen in other Asian countries (e.g., Kim et al. 2013), inquiry-based instruction in everyday practice in China is challenging because of teachers’ emphases on mastering content knowledge, students’ heavy workloads, and assessment anxieties in the educational system (Huang and Mao 2013). The aforementioned intentions for holistic student learning that fall under the umbrella of “quality education” (suzhi jiaoyu) reforms have been hard to implement evenly or successfully across this vast and populous country (Dello-Iacovo 2009).

Under the overall goals of the curriculum, content standards are listed and grouped into five main categories: (1) scientific inquiry, (2) scientific attitudes and values, (3) life science, (4) physical science, and (5) earth and space science. The content standards in each category are stated in accordance with the level of difficulties, i.e., from easy to hard to achieve. Unlike other countries, the learning standards are not grouped by grade levels: The curriculum developers explained that grouping standards by the level of difficulties rather than grades would provide more space and choices for textbook publishers, and implement the policy of “one standard, multiple versions of textbook” (Zhong 2009). The flexibility and openness of content and learning outcomes for each grade could potentially develop thoughtful and appropriate decision making by teachers in various regions and communities. However, the nature of integration as well as openness of the curriculum structure without specific learning objectives for students’ grade levels has been challenging for curriculum developers/implementers to make decisions on cognitive characteristics in the formation and development of scientific literacy (Huang and Mao 2013). Thus, in the draft of a newly recommended science curriculum, the content standards were grouped by grade levels (e.g., Primary Science Curriculum Standard Revision Project Team 2013, 2014).

Science textbooks are the main resource of science teaching and in some rural areas, it may be the only resource available for teachers. Thus, it is critical to know
what content, activities, and guidelines for learning are provided in science textbooks bearing in mind unique contextual factors. In China, there are three main versions of science textbooks, published by the Education Science Publishing House, People’s Education Press and Jiangsu Education Press. In the 2001 curriculum document, there are also suggestions of teaching and learning activities, assessment, development and utilization of curriculum resources, and teachers’ professional development to assist teachers and schools in planning and implementing the curriculum. In sum, the science curriculum in China has experienced tremendous changes in terms of the curriculum goals, content matter, and pedagogical approaches over the years (Wei 2010).

**Overall National Profile of Learning Objectives**

In Table 4.9, the majority of learning objectives from China are clustered around Understand-Conceptual (29.0 %). Like other states, certain knowledge-process combinations (Remember-Factual, Understand-Conceptual, Apply-Procedural) were also observed to be the dominant pattern (those three accounted for 56.2 % of items in the intended curriculum). In the cognitive dimension, Remember (29.6 %) and Understand (38.9 %) accounted for most of the items with relatively few in the category of Analyze, Evaluate, and Create. In terms of knowledge, it can be seen that Conceptual was the major category accounting for over half (54.3 %) of the items. Factual and Procedural items held lower percentages, and only a single item is in Metacognitive. Learning standards are not categorized in grade levels, thus, there are no tables of learning objectives sorted according to grade levels for mainland China (see Appendix A).

<table>
<thead>
<tr>
<th></th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Number of knowledge items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>29 (67.4) (60.4)</td>
<td>14 (32.6) (22.2)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>43 (26.5)</td>
</tr>
<tr>
<td>Conceptual</td>
<td>19 (21.6) (39.6)</td>
<td>47 (53.4) (74.6)</td>
<td>17 (19.4) (53.1)</td>
<td>4 (4.5) (66.7)</td>
<td>1 (1.1) (20.0)</td>
<td>0</td>
<td>88 (54.3)</td>
</tr>
<tr>
<td>Procedural</td>
<td>0</td>
<td>1 (3.3) (1.6)</td>
<td>15 (50.0) (46.9)</td>
<td>2 (6.7) (33.3)</td>
<td>4 (13.3) (80.0)</td>
<td>8 (26.7) (100)</td>
<td>30 (18.6)</td>
</tr>
<tr>
<td>Metacognitive</td>
<td>0</td>
<td>1 (100.0) (1.6)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1 (0.6)</td>
</tr>
<tr>
<td>Number of cognitive items</td>
<td>48 (29.6)</td>
<td>63 (38.9)</td>
<td>32 (19.8)</td>
<td>6 (3.7)</td>
<td>5 (3.1)</td>
<td>8 (4.9)</td>
<td>162</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
Taiwan

General Introduction

The national primary curriculum in Taiwan consists of eight main learning areas: literature (including Chinese, English, and other local/ethnic language), health and physical education, social studies, arts, math, science, and integrated activities. In parallel with those learning areas, it also includes seven major issues, which are supposed to be embodied in each of those learning areas. The seven major issues are: Gender equality, environmental education, information education, education of household management, human rights education, career development education, and marine education. In other words, by learning the primary science curriculum, students also have the opportunities to explore those major issues.

Even though the latest analysis of the 2008 primary science curriculum in Taiwan was published eight years ago by Chiu (2007), it remains the most comprehensive to date and will be referred to extensively here. Since the mid-1990s, science curriculum development in Taiwan has been very much influenced by policy documents from the United States of America. These influences, nonetheless, are to be subsumed under the two main thrusts of educational reform efforts in Taiwan, which are the improvement of equal and excellent opportunities to education among learners (Peng et al. 2011). Chief among the reform recommendations for improving science teaching then was to emphasize inquiry-based instruction, which struggled (as with so many other states) with superficial implementation of such difficult teaching approaches (Abd-El-Khalick et al. 2004). The curriculum structure consists, for our purposes, of three levels: Grades 1–2 (Level 1, life curriculum), Grades 3–4 (Level 2, integrated science and technology curriculum), and Grades 5–6 (Level 3, integrated science and technology curriculum). The general aims of the science and technology curriculum in Taiwan are as follows:

- Cultivate interest and passion for scientific inquiry and to develop habits of active learning
- Learn the methods of science and technology during inquiry and be able to apply these to present and future life
- Develop care for the environment, to conserve resources, and to respect life
- Be able to communicate, work in teams, and work in harmony
- Develop and stimulate the potential for independent thinking and problem-solving skills
- Be aware of and explore interactions between Man and technology.

There are also eight main topics that comprise scientific literacy in the curriculum and are the following:

1. Process skills
2. Knowledge of science and technology
3. Nature of science and technology
4. Development of science and technology
5. Scientific attitudes
6. Habits of thinking
7. Applications of science
8. Design and production.

Five major topical areas further structure the learning standards or guidelines: Composition of materials and the earth’s environment; uses of nature; life and the environment, and sustainability. There are no national exit exams at the end of primary school in Taiwan although it has been reported that adequate coverage of content matter by teachers very anxious of time constraints in a crowded curriculum have been pressing concerns for teachers in the previous decade (Abd-El-Khalick et al. 2004). We note with some regret that while Taiwanese science education researchers are among the most prolific in Asia in terms of their representation in the top international journals, their focus from 1998 to 2007 has predominantly been on empirical teaching-learning research/methods at secondary levels (Tsai and Wu 2010). In-depth studies in English on the curriculum in Taiwan, especially at the elementary grades, have not picked up since that previous review (see also Chen et al. 2010). In Appendix B, we list down the learning objectives (excluding those in the affective domain e.g., [5] Habits of Thinking) from Taiwan.

**Overall State Profile of Learning Objectives**

In Table 4.10, it is clear that learning objectives from Taiwan in the cognitive domain span the whole range of categories with the majority in Apply (38.6 %) and a very respectable number in Create (10.5 %). Conceptual and Procedural both accounted for 82.5 % of items in the knowledge domain. And if the first three knowledge-process combinations are all added together, they account for 71.1 % of the learning objectives from Taiwan.

The pairing of Procedural-Apply moreover garnered nearly a third of all Taiwanese learning objectives, which points to the extremely strong emphasis on achieving understanding of scientific concepts and skills through practical activities. Lu and Lien (2016) have confirmed this inherent bias towards laboratory work when they reported that teachers’ responses on the following questions (from TIMSS 2011) concerning the frequency of activities in local classrooms were above international averages (in the USA, the Russian Federation, Korea, Singapore, and Japan):

- Observe natural phenomena such as the weather or a plant growing and describe what they see
- Watch me[the teacher] demonstrate an experiment or investigation
- Design or plan experiments or investigations
- Conduct experiments or investigations.
On the other hand, the frequency of responses from Taiwanese teachers to the following questions were the lowest in their international comparative study:

- Read their textbooks or other resource materials
- Have students memorize facts and principles
- Give explanations about something they are studying
- Relate what they are learning in science to their daily lives
- Take a written test or quiz.

**Profile of Upper and Lower Primary Learning Objectives**

As mentioned, there was a clear emphasis on Procedural (and its concrete manifestation through practical work) in the Taiwanese curriculum. Hence, it comes as no surprise that in Table 4.11 we observe that across all grade divisions this category predominated, with Conceptual equal or a close second in terms of representation (other than Grades 3–4). Conversely, items in Factual were not as

<table>
<thead>
<tr>
<th>Grade</th>
<th>Factual</th>
<th>Conceptual</th>
<th>Procedural</th>
<th>Metacognitive</th>
<th>Total (n = 114)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>1 (4.8)</td>
<td>10 (47.6)</td>
<td>10 (47.6)</td>
<td>0</td>
<td>21 (18.4)</td>
</tr>
<tr>
<td>3–4</td>
<td>8 (25.0)</td>
<td>7 (21.9)</td>
<td>17 (53.1)</td>
<td>0</td>
<td>32 (28.1)</td>
</tr>
<tr>
<td>5–6</td>
<td>10 (16.4)</td>
<td>23 (37.7)</td>
<td>27 (44.3)</td>
<td>1 (1.6)</td>
<td>61 (53.5)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
numerous other than when in Grades 3–4. As children progress in primary school, it is to be noted that the number of science learning objectives increases from 21 to 32 to 61, a threefold increase from the earlier years.

The trend toward practical knowing in science was likewise reflected in Table 4.12 for the number of items in Apply accounted for the vast majority of objectives across two of the three divisions while they were tied with items in Understand in Grades 5–6. We observe too that items in Create were represented at all divisions though more so in the latter two. Finally, it was reported by Lu and Lien (2016) that the content distribution of Grade 4 textbooks in Taiwan were biased toward physical science topics; percentages of topics on biology, physical science, and life sciences were 29.8, 39.1, and 18.5 % compared to international averages of 38.1, 25.3, and 23.1 % respectively.

Table 4.12 Number of learning objectives in the cognitive domain from Taiwan sorted according to their grade levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1–2</td>
<td>1 (4.8)</td>
<td>5 (23.8)</td>
<td>13 (61.8)</td>
<td>1 (4.8)</td>
<td>0</td>
<td>1 (4.8)</td>
<td>21 (18.4)</td>
</tr>
<tr>
<td>3–4</td>
<td>8 (25.0)</td>
<td>4 (12.5)</td>
<td>12 (37.4)</td>
<td>2 (6.3)</td>
<td>2 (6.3)</td>
<td>4 (12.5)</td>
<td>32 (28.1)</td>
</tr>
<tr>
<td>5–6</td>
<td>10 (16.5)</td>
<td>19 (31.1)</td>
<td>19 (31.1)</td>
<td>3 (4.9)</td>
<td>3 (4.9)</td>
<td>7 (11.5)</td>
<td>61 (53.5)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

The Republic of Korea

General Introduction

The 2015 science curriculum aims to develop students’ scientific literacy to solve individual and social problems scientifically and creatively. This was to be accomplished through understanding essential scientific concepts and developing inquiry skills (MOE 2015). The specific goals stated in this new curriculum are as follows:

1. Students cultivate attitudes of curiosity toward scientific problem-solving and have interest in natural phenomena
2. Students develop abilities to scientifically inquire about natural phenomena and everyday problems
3. Students understand essential scientific concepts through inquiry about natural phenomena
4. Students understand the interrelationships among science, technology, and society and develop citizenry literacy in a democratic society based on this understanding.

5. Students cultivate lifelong learning abilities through recognizing the joy of science learning and application of science.

Science is taught from K-12 in Korean school systems but science as a separate subject is taught only from Grades 3 to 12. This means that there are no specific science units or learning objectives stated for K-2 levels in the national science curriculum. In Grades 1–2, subjects include the Korean language, Mathematics, and three integrated subjects: Intelligent Life, Disciplined Life, and Pleasant Life. Science is included under the subject of Intelligent Life. From Grades 3–9, science is taught as an independent subject and later in Grade 10, Integrated Science and Science Inquiry Experiments are also included. In Grades 11–12, science is divided into more specific disciplines such as physics, chemistry, life science, and earth and space science, history of science, science and everyday life, and interdisciplinary science. Thus, in primary schools, children in Grades 1–2 learn science in the Wise life subject and only in Grades 3–6 then they learn science as an independent school subject.

The primary science curriculum has four overall dimensions; Movement and energy, Matter, Life, and Earth and space. Each dimension includes several topics. The science topics in Grades 3–4 include the characteristics of materials and matters, usage of magnets, lives of animals, changes of the earth surface, lives of plants, strata and fossils, states of matters, characteristics of sound, weight, lifecycles of animals, volcanoes and earthquakes, separation of mixtures, lifecycles of plants, changes of states of water, shadows and mirrors, shape of the earth, and the movement of water (integrated topic). Science in Grades 5–6 includes temperature and heat, the solar system and stars, dissolution and solution, various living beings and our lives, life and the environment, weather and our lives, movements of objects, acids and bases, movements of the earth and moon, various gases, light and lenses, structures and functions of plants, usage of electricity, seasonal changes, combustion and fire extinction, structures and functions of our bodies, and energy and everyday lives (integrated topic). The two integrated topics are newly included in 2015 science curriculum to develop integrated science learning and knowledge application.

The topics and units in the primary science curriculum are developed in consideration of the level of children’s cognitive development and interconnections throughout the grade levels and it is explained in the science curriculum. Here is one example (Table 4.13) of knowledge connection on electricity and magnetism from primary Grades 3–6 to middle year Grades 1–3.

In the 2015 science curriculum (see Appendix C), each unit introduces specific learning objectives and inquiry activities, which are part of mandatory elements for teaching. It is a unique feature of Korean curriculum that these inquiry activities are stated in connection with learning objectives to emphasize the importance of inquiry teaching. For instance, the first unit in Grade 3 science is Characteristics of
In this unit, four learning objectives and three inquiry activities are introduced as shown below.

Learning objectives:

1. By comparing objects made of different materials and matters, students can make connections between functions and characteristics of objects.
2. Compare various characteristics of materials and matters by observing objects with the same shapes and sizes but different materials and matters.
3. Explain the changes of characteristics of matters by observing the differences made between before and after different matters are mixed.
4. Design various objects with various materials and matters and discuss their strengths and weakness.

Inquiry activities:

- Investigate what matters and materials objects are made of
- Relate the functions and characteristics of objects
- Observe changes in characteristics of materials and matters.

There is thus a brief instruction on the interpretation of learning objectives, instructional guide, and assessment guide in the science curriculum but the details of those ideas are explained in teachers’ guidebooks which are to be developed much later after the curriculum is released. During this period of curriculum reform, a team of science teacher educators, primary science teachers, and scientists develop the science textbooks and teacher guidebooks. This team is assembled by the government and the science textbooks and teacher guidebooks developed by
this team become the official resources that all primary school teachers use as a working version of science curriculum across the nation. The mandatory teaching hours of science is about 102 h per year. In most of primary schools, science is taught by homeroom teachers in Korea as normally seen in other countries.

**Overall National Profile of Learning Objectives**

Table 4.14 shows that 79.6% of learning objectives belong to Conceptual and 19.5% are in Procedural. In terms of cognitive processes, 62% are located in Apply, 34.5% in Understand, and 3.5% in Create. In the Korean curriculum, there are more items in the Conceptual:Apply pair \( n = 51 \) than in Conceptual:Understand \( n = 39 \) and Procedural:Apply \( n = 18 \). This can be explained by how the learning objectives in the new 2015 science curriculum were structured; many learning objectives require students to conduct activities to achieve the understanding of scientific concepts. For example, one of the learning objectives in Grade 3–4, “By comparing objects made of different materials and matters, students can make connections between functions and characteristics of objects,” students have to compare objects, substances, and materials (Apply) in order to understand the relationships between functions and characteristics of the objects (conceptual knowledge). In the latest science curriculum reform “by doing,” i.e., students’ actions are emphasized more than in the previous version of science curriculum in 2009, thus, the proportion of Apply-Conceptual pairing are more frequent than the Understand-Conceptual one (Lee et al. 2015; Na et al. 2015). Compared to the

<table>
<thead>
<tr>
<th>Table 4.14</th>
<th>Table showing total number of learning objectives ( n = 113 ) from Korea classified according to the dimensions of knowledge and cognitive processes in RBT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Remember</td>
</tr>
<tr>
<td>Factual</td>
<td>0</td>
</tr>
<tr>
<td>Conceptual</td>
<td>0</td>
</tr>
<tr>
<td>(100.0)</td>
<td></td>
</tr>
<tr>
<td>Procedural</td>
<td>0</td>
</tr>
<tr>
<td>(25.7)</td>
<td></td>
</tr>
<tr>
<td>Metacognitive</td>
<td>0</td>
</tr>
<tr>
<td>Number of cognitive items</td>
<td>0</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
previous curriculum, factual knowledge was significantly reduced. Overall, it is clear that Conceptual and Apply are emphasized in the recent science curriculum 2015.

Profile of Upper and Lower Primary Learning Objectives

The number of learning objectives for Grades 3–4 and Grades 5–6 are almost equal \((n = 57\) in Grades 3–4, \(n = 56\) in Grades 5–6). In the span of the knowledge dimension and cognitive processes in lower and upper grade levels, there are few differences in the Korean curriculum (see Tables 4.15 and 4.16). In terms of knowledge, 78.9 % of items belong to Conceptual in Grades 3–4 and 80.3 % in Grades 5–6. There is only one learning objective in Factual in Grades 5–6 with none in Metacognitive. For cognitive processes, Understand takes up about 20 % and Apply about 62 % of all the learning objectives. There are three learning objectives in Create in Grades 3–4 and one in Grades 5–6.

Singapore

**General Introduction**

The latest primary science syllabus in Singapore took effect in 2014 (see CPDD 2013) with a renewed emphasis on teaching and learning science via inquiry. Inquiry was the unifying idea in a broad framework that included knowing science in daily life, in society, and the environment as shown in Fig. 4.1.
Knowing subject matter here is understood in terms of two aspects (i) knowledge, and (ii) understanding with application: the former is the more fundamental and can be considered analogous to the first level of the knowledge domain in RBT while the latter finds affinities with the second and third levels in RBT. In common with many other countries, the learning of skills and process in science is also felt to be fundamental together with cultivating wholesome ethics and attitudes in science. This curriculum document further associate the learning of science with a number of so-called twenty-first century competencies: A flexible set of skills and values as the “outcomes of individuals able to thrive in and contribute to a world where change is the only constant” (CPDD 2013, p. 3). Another important goal of learning science in Singapore is the achievement of scientific literacy, which was described here using words adapted from the PISA 2006 science framework. No longer was there a fixation on merely memorization of more and more facts, but instead evidence-based reasoning, and application of knowledge to make decisions in the real world are seen as highly desirable.

The syllabus is very specific in spelling out the overall aims of learning primary science that mirror the science curriculum framework:

- provide students with experiences which build on their interest in and stimulate their curiosity about their environment
- provide students with basic scientific terms and concepts to help them understand themselves and the world around them
- provide students with opportunities to develop skills, habits of mind, and attitudes necessary for scientific inquiry

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**Fig. 4.1** The science curriculum framework for primary schools in Singapore. (The Government of Singapore (c/o Ministry of Education) owns the copyright to the figure and the figure is reproduced with their permission.)
• prepare students toward using scientific knowledge and methods in making personal decisions
• help students appreciate how science influences people and the environment (see CPDD 2013, p. 5).

In terms of the organization of science content, the learning outcomes are grouped into five integrated themes (Diversity, Interactions, Systems, Cycles, Energy). Although somewhat arbitrary, these groupings were thought to be able to “communicate a more coherent and integrated understanding of science that bridged the life science-physical science divide” (Chin and Poon 2014, p. 33). Again, the agency of students is underscored as they are supposed to be critical inquirers in science under the guidance of the teacher who plays the role of the leader or facilitator of inquiry (Fig. 4.1).

To assist teachers in planning and implementing inquiry-based lessons, the syllabus suggests a useful scaffold for inquiry—the five essential features that originated first in the Biological Sciences Curriculum Study (BSCS) (Loucks-Horsley and Olson 2000). Within this framework, it allows educators to plan a spectrum of teacher- and student-centered modes of teaching. In this state, the syllabus is divided into two blocks: lower- (Grades 3–4) and upper-primary (Grades 5–6). Due of the presence of exit examinations (in four subjects including science) at the end of Grade 6 in Singapore, many researchers have reported that the intended curriculum was largely isomorphic with the taught and tested curriculum (Hogan et al. 2013). The grammar of schooling, not just in science, means that local teachers are very sensitive to assessment concerns despite their familiarity and personal beliefs about teaching science via inquiry.

**Overall National Profile of Learning Objectives**

According to Table 4.17, the majority of learning objectives from Singapore clustered around Understand-Conceptual (48.3 %) in alignment with most other school curricula (see Appendix D). Certain knowledge-process combinations (Remember-Factual, Understand-Conceptual, Apply-Procedural) were observed to be the dominant pattern here as well; they accounted for 65.1 % of items in the intended curriculum. It is interesting to note that no item appeared beyond Analyze nor were there any representations in Metacognitive. An earlier coding of items in Lee et al. (2015) showed that Understand garnered 60.2 % of all learning objectives while those in Remember were just 13.3 %. Moreover, these authors reported that items in Procedural were about 10 % higher and those that fell in Conceptual were lower by the same amount. We believe that the current Table 4.17 is a more accurate portrayal of the spread of objectives from Singapore; we have improved our coding abilities using RBT that is consistent across all six states (not just two) surveyed in this book.
From Tables 4.18 and 4.19, we see that as children move from lower to upper-primary levels, the number of objectives increased by 13.1% in Conceptual mainly at the expense of Factual items. With respect to cognitive processes, however, there was little change for most processes over this same period. Science teaching in lower primary occupies about 90 min per week that increases to about 150 min in upper-primary, which can therefore account for the 59% increase (from 47)

Profile of Upper and Lower Primary Learning Objectives

Table 4.17 Table showing total number of learning objectives ($n = 83$) from Singapore classified according to the dimensions of knowledge and cognitive processes in RBT

<table>
<thead>
<tr>
<th></th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Number of learning items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factual</td>
<td>14 (100) (53.8)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14 (16.9)</td>
</tr>
<tr>
<td>Conceptual</td>
<td>12 (21.4) (100)</td>
<td>27 (48.2)</td>
<td>13 (23.2) (50.0)</td>
<td>4 (7.2)</td>
<td>0</td>
<td>0</td>
<td>56 (67.5)</td>
</tr>
<tr>
<td>Procedural</td>
<td>0</td>
<td>0</td>
<td>13 (100.0)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>13 (15.6)</td>
</tr>
<tr>
<td>Metacognitive</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Number of cognitive items</td>
<td>26 (31.4)</td>
<td>27 (32.5)</td>
<td>26 (31.4)</td>
<td>4 (4.7)</td>
<td>0</td>
<td>0</td>
<td>83</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

Table 4.18 Number of learning objectives in the knowledge domain from Singapore sorted according to their grade levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Factual</th>
<th>Conceptual</th>
<th>Procedural</th>
<th>Metacognitive</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–4</td>
<td>8 (25.0)</td>
<td>19 (59.4)</td>
<td>5 (15.6)</td>
<td>0</td>
<td>32 (38.6)</td>
</tr>
<tr>
<td>5–6</td>
<td>6 (11.8)</td>
<td>37 (72.5)</td>
<td>8 (15.7)</td>
<td>0</td>
<td>51 (61.4)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)

Table 4.19 Number of learning objectives in the cognitive domain from Singapore sorted according to their grade levels

<table>
<thead>
<tr>
<th>Grade</th>
<th>Remember</th>
<th>Understand</th>
<th>Apply</th>
<th>Analyze</th>
<th>Evaluate</th>
<th>Create</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>3–4</td>
<td>10 (31.3)</td>
<td>9 (28.1)</td>
<td>11 (34.4)</td>
<td>2 (6.2)</td>
<td>0</td>
<td>0</td>
<td>32 (38.6)</td>
</tr>
<tr>
<td>5–6</td>
<td>16 (31.3)</td>
<td>18 (35.3)</td>
<td>15 (29.4)</td>
<td>2 (4.0)</td>
<td>0</td>
<td>0</td>
<td>51 (61.4)</td>
</tr>
</tbody>
</table>

Percentages shown in brackets (%)
32 to 51) in learning objectives during this period. Note again our warnings against simple counting of the changes in the numbers of objectives earlier; there are good rationales for these frequencies as children move up grade levels.

References


CDC. (2011). *General studies for primary schools curriculum guide (Primary 1-Primary 6)*. Hong Kong SAR: The Education Bureau.


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