INVITATION TO JAPANESE MATHEMATICS TEXTBOOKS

Japanese culture in mathematics textbooks

KEIRINKAN

Arithmetic and Mathematics

Hideki Iwasaki [Supervisors of Fun with MATH]

Introduction

"The Earth is blue." These words were uttered by the first human being to orbit the globe from outer space as he looked upon a sphere covered in water and teeming with life. This may have marked a turning point for us, as we began to see our world as a planet for the first time and to consider environmental issues and other questions that transcend national borders. It was the moment we became passengers on Spaceship Earth. Prior to that, we pictured the globe as superimposed with a jumbled collection of colored nations; at that moment, however, it transformed into a single spaceship that was "global" in the truest sense.

I had a revelation once while speaking to a university professor of English education, who made an eloquent observation:

> Our English education system is often criticized, since the fact that many Japanese struggle with English is blamed for our difficulties communicating with people outside of Japan. The reality though, is that we Japanese struggle with communication in general—and this is why we are no good at English.

These wise words are clear enough without an explanation, but to look at it further, the reality is that the frustration of wanting to interact more with non-Japanese and not being able to because of an English language barrier has become commonly accepted among the Japanese. If we turn this idea around, the Japanese language is the obstacle that prevents outsiders from getting closely involved with Japan. Whether in economics, politics, or academics, Japanese language and culture are cited as an excuse for others' reluctance to interact with Japan on equal terms. As long as we continue to blame words for our communication problems, we demonstrate that we intend to remain blithely irresponsible for our shortcomings.

We now realize, however, that our world is increasingly entering a knowledge-based era. This means that new knowledge, information, and skills are dramatically increasing in importance as they provide the foundation for activities being carried out in all corners of society—particularly in politics, economics, and culture. Unlike currency, knowledge, information, and skills do not bear the seal of any nation, and do not come with an exchange rate. It is high time for the Japanese to stop hiding behind a language barrier that secretly affords us the pleasure of not taking responsibility for where we stand.

When it comes to the future of our societies and our world, we need to think of ourselves as living not in a world map, but on a globe unmarked by national borders. Knowledge and human resources should not be bound by nationality; they must be allowed to freely roam the earth. If different cultures and civilizations cannot coexist and cooperate, there is no way we can resolve our global problems. Even local problems are part of an interconnected worldwide network, and if we do not understand their true significance, we cannot address them in the proper way.

Arithmetic and mathematics

When we look at mathematics education from this perspective, labeling our textbooks with the word "math" seems far more global than the word "arithmetic". In fact, in 1994 the National Council of Teachers of Mathematics (NCTM) abolished the publication *Arithmetic Teacher*, which had been in print for over 40 years, and replaced it that same year with *Teaching Children Mathematics*. In the statements issued regarding the discontinuation and establishment of these publications, the NCTM declared that even if their educational systems were different, arithmetic had been passed down and evolved into mathematics in the US. It was also noted that children in the parts of East Asia that have Chinese character–based writing systems (such as China, Korea, and Taiwan) were using mathematics, not arithmetic, from the time they were in primary school. Finally, it seemed unnecessary to differentiate between arithmetic and mathematics in countries that, like Japan after World War II, combined primary and lower secondary education under their compulsory education programs. Math was thus treated in the same way as science. However, from 1941 through the present day, the reality is that primary school children use arithmetic in primary school and mathematics in secondary school—so there must be an underlying, uniquely Japanese logic to the subject.

Naturally, the education system has a powerful influence on the way textbooks are named. Prior to World War II, secondary education in Japan was considered preparation for higher education, while primary school was treated as a complete education that prepared people for everyday life. If we still lived in those times, there would be a natural break in mathematics education between the primary and secondary level—and it would be completely appropriate for one side to be called "arithmetic" and the other "mathematics". However, given the advent of the post-war one-track educational system and the fact that upper secondary education is increasingly compulsory from a practical standpoint, we may be better off integrating the entire system under the heading "mathematics". With textbooks though, the real issue is not this kind of institutional integration, but developing awareness in children. So the retaining of different names for elementary and junior high school textbooks is not merely a historical relic, but is instead considered an accurate reflection of distinct learning stages. This is the critical concept underlying the "arithmetic" and "mathematics" distinction used the English versions of the textbooks as well.

From the perspective of translation

Mathematics deals with numbers and figures—in other words, abstractions. It is impossible to start with an abstraction, however: we must begin with something that relies on context and then arrive at the abstraction by creating something that does not rely on that context. Furthermore, without the ability to perform this intellectual exercise, we are stuck making narrow-minded assessments based only on actual experience—stuck in a claustrophobic world where only individual characters dominate, and where there is no hope of achieving universalization. Arithmetic, however, demands that we rely on context, and I will always remember the comment from the textbook translation supervisor on the next page: "The English expressions used in our translation project are sometimes stiff or unwieldy as a result of our decision to go with a word-for-word translation of the original Japanese." Apparently, sticking closely to the logic of arithmetic requires faithful effort. For example, the original Japanese skillfully uses words of Japanese origin or words of Chinese origin to communicate equivalent meaning, based on children's level or understanding; furthermore, Japan has also adopted the decimal system and breaks large numbers every four places instead of three. If we try to translate these concepts into a Western language, we will necessarily come up short, as they rely on a numeration structure that is not found in Western linguistic usage. Everything depends on our choice of translation style—should we use normal English that communicates a Western way of thinking when dealing with digital systems and wording, or should we emphasize Japanese-style education system?

Of course, this is just one example. In terms of distinguishing part-based division and measurement-based division, we focused on emphasizing the difference in perspective between two and the skills needed to classify fractional concepts, which Westerners do not have. These techniques rooted children's everyday lives and used for teaching math in Japan included elements that refused simple translation. The same applies to the form of abstract concepts. Though it may seem obvious since junior high school mathematics is simply a higher form of arithmetic, there is a critical sentence in the first-year junior high school (seventh grade in the US system) textbook that tells students that *kahō* (the algebraic word for addition) is the same process as *tashizan* (the arithmetic word for addition, something akin do "doing sums"). However, since they both are translated the same way in English, we are left with the superfluous statement "addition is the same as addition". Furthermore, we get no sense of a transition from an arithmetic operation to an algebraic one. Although this is a critical development, it simply cannot be translated into English. We ran into the same problem with multiplication. The 10,000 (*man*)–based numeration system was another translation pitfall, albeit of a different nature. Translating simply resulted in tautological sentences, so in the end they were omitted from the translated textbook. However, just because something cannot be translated does not mean that it is insignificant; on the contrary, it may be important precisely for that reason. It is fair to say that therein lies the deep significance of Japanese arithmetic and mathematics education.

Globalization must coexist with things that cannot be globalized, and destroying important underlying concepts in the interest of smoothing out the surface does more harm than good. The reason that mathematics and philosophy are thought to be so closely related is because mathematical concepts are deeply tied to the fundamental ideas that lie at the core of the human mind. At the deepest levels all human beings are the same, and the work of exposing those levels through the use of symbols naturally puts us in touch with an inherent universality. That is why mathematics serves the critical role of forming the underlying structure for all areas of science and technology, and why mathematics is universal in nature. The classroom is where students take their first steps into the world of mathematics, and we hope that the teachers who will use this textbook in the years to come will understand just how critical and fundamental these steps are. At the very least, we hope that an understanding of the cultural difficulties associated with translation and the fact that certain concepts simply cannot be translated will help them realize just how deeply significant it is to guide people along the path to learning arithmetic and mathematics.

Conclusion: Issues in education

It goes without saying that the way education works is deeply rooted in our societies and our era. If it did not, it could not serve as the foundation for societies and individuals to recognize the changes and demands that the times place on them and match their pace and scope. It is for this reason that education must take on a variety of forms depending on when and where it is practiced.

On the other hand, it is possible to go from these characteristics of teaching to imagine a kind of borderless curriculum, and mathematics and arithmetic are no exception. The ups and downs of educational reform in arithmetic and mathematics—some of which become global in scale—will cause the nations who are affected by them to do things differently, whether it is building a curriculum, assessing students, or completing curricula.

Arithmetic and mathematics education is being carried out day after day, all over the world, blending together the universality of math with the distinctive characteristics of education. In the end, our job as translators may simply be the usual task of building bridges between people—but in the course of our effort here, one cannot help but feel that we have stumbled upon a precious opportunity to unearth some of the fundamental issues in arithmetic and mathematics.

Profile

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Educational Considerations and Culturally Sensitive Translation in Japanese Mathematics Textbooks

Takuya Baba [Translators of Fun with MATH]

Beginning in the late Edo period and continuing through the early Meiji, translated textbooks played a vital role in the modernization and spread of mathematics education in Japan.

Though we realize it would be presumptuous to liken our current translation project to those historic efforts, we nevertheless mention them at the outset in the hopes that they might serve as a springboard for our inquiry into the significance of the work of translation itself.

Early translation projects were carried out in an effort to adopt and assimilate educational programs and content that had not previously existed in Japan. In contrast, today's smartphones and other convenient devices mean that we now live in an era where we can instantly listen to or read a translation simply by starting a conversation or pointing out areas that we are unsure of. If the goal of translation is to take in information, we can accomplish this with little or no effort; furthermore, all kinds of information are available in English, and accessing these sources gives us the sense that we are staying on the cutting edge.

We need to stop and really think, however, about the ability of translation to take the diversity inherent in the thousands of languages spoken by the thousands of ethnic groups around world and simply express it in English in the name of globalization. Furthermore, we need to consider the significance of translating the mathematics textbooks used in Japan of Far East Asia.

The English expressions used in our translation project are sometimes stiff or unwieldy as a result of our decision to go with a word-for-word translation of the original Japanese. In our view, the above diverse cultures and languages of our world have given rise to unique phenomena and distinctive interpretive frameworks that come from a focus on particular perspectives—characteristics that are the result of centuries of cultural activity rooted in the geography and climate of each region. For example, the Japanese and those in many other Asian countries have many words associated with a rice-based diet, while it is likely that Europeans and Americans have an abundance of expressions related to wheat and other grains.

Bishop (1991) has said of the multiplicity of cultural contexts for mathematics education, "the mathematical activity belonging to each culture is diverse while also being universal." He lists six universal activities: counting, measuring, designing, locating, explaining, and playing. For example, while there may be different types of counting numbers (numeration) or writing numbers (numerical notation), no culture exists without numbers themselves.

In choosing to use word-for-word English expressions in this project, we began with concern over the possibility of disregarding the gaps between cultural frameworks in the interest of achieving a smooth translation. A single error could give rise to misunderstanding—and it was possible to fall into the trap of forgetting there was a misunderstanding there in the first place. Of course, a translation that couldn't be understood at all would cause its own problems.

Thanks to this approach, translating these textbooks became an intellectual exercise whereby we sought to gain a deeper understanding of mathematical education in Japan. We were careful to pit our own unconscious perspectives against other perspectives in order to become more aware of them. Particularly when there was no one-to-one equivalent translation of a given concept, we tried to come up with expressions while retaining an awareness of the representational gaps they created. Our efforts resulted in unexpected delight if we were able to produce not only a linguistic translation, but also one that captured some of the cultural features underlying the original concept as well.

To return to the beginning, our English translation of these mathematics textbooks began when a Keirinkan representative visited my room in 2010. The Japan International Cooperation Agency (JICA), which supports education in Africa and many other developing countries, at the time had an interest in the quality of the textbooks and educational materials that incorporated systematics from the Japanese curriculum, and was in the process of developing science materials that included curriculum systematics in Kenya while making use of its expertise as a textbook publishing company. Several people had proposed extending the project to mathematics, but the idea had not gone forward, inspiring Keirinkan's long-awaited visit.

The details of that conversation are somewhat hazy now, but I do clearly remember discussing market potential and Keirinkan's corporate social responsibility (CSR) as a textbook publisher. In typical Kansai fashion, I discussed that the project was unlikely to make a profit; this was attributed to the fact that several European publishers (including Macmillan, Heinemann, and the Oxford University Press) had already established local operations in Africa, that sales growth was unlikely in such impoverished nations, that educational programs and curricula were different in each country, and on and on. Still, Japan was currently in the spotlight for the quality of its mathematics education, and I explained that producing an English translation of a textbook was meaningful for Keirinkan in terms of the company's social responsibility as one of the premier publishers of textbooks approved by the Ministry of Education.

Once we decided to go ahead with the project, we needed to put together a translation team—and we wanted the best one possible. Professional translators were brought in to do the translation itself, while the university supplied experts to thoroughly check their work from the perspective of mathematics education. The team included academics who had been involved in writing mathematics textbooks in Japanese, university professionals experienced in international cooperation, teachers, and others who pored over the manuscript from a wide variety of perspectives. Finally, the entire document was carefully checked by prominent researchers in the US.

The following guidelines were set forth prior to beginning the English translation:

- Preserve the nuances of the Japanese wherever possible
- Provide commentary explaining aspects of Japanese mathematics culture
- Translate using terms appropriate to each grade level

We arrived at the above guidelines by remaining keenly aware of the unique features of Japanese culture and language—features that could not be disregarded during the process of translating the text. A few specific examples of how we applied these guidelines are given below.

Preserve the nuances of the Japanese wherever possible

- Expressions such as 5 *kobun* appear throughout the text. Though there is no direct translation for them in English, we used different fonts to indicate that they represented a uniquely Japanese way of looking at things.
- The use of grammatical tense (such as future or past) and mood (such as the subjunctive) was the subject of extensive debate. Though the Japanese language often does not clearly distinguish tense or mood, we were forced to make specific choices when translating the more vague Japanese usage into an English grammatical structure.
- English and Japanese switch the order of the multiplier and multiplicand when expressing multiplication. The difference is whether the number of elements in a group and the number of groups become multiplicand and multiplier or vice versus. We consistently used Japanese word order.
- Another difficult task was dealing with the way different number places are read in English. The number 100,000 represents a hundred thousands in English, but ten ten-thousands (*man*) in Japanese. In this case, we translated the place as ten man in order to explain the repetition of ones, tens, hundreds, and thousands places.

Provide commentary explaining aspects of Japanese mathematical culture

Another critical feature of the text was the preparation of annotated commentary. The footnotes in the text introduce certain aspects of Japanese culture and systems or its mathematics education culture that could not be included in the main text.

Examples of the culture and systems mentioned are the textbook screening system, Japanese calendar, and school lunches. Knowledge of the textbook screening system is relevant to how textbooks themselves are regarded in Japanese society, while information on the Japanese calendar, school lunches, and other aspects of culture provide a foundation for understanding life in Japanese schools and the community. In looking at the way we might construct these cultural features for inclusion in a textbook, we hoped to make it clear that introducing culture was an important function of a translated textbook as well.

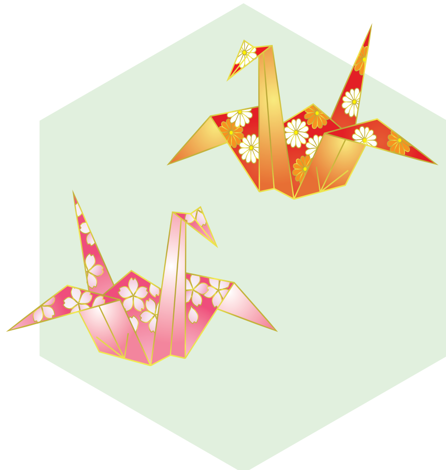
Examples of Japan's mathematics education culture include persimmons, the use of the Chinese character "正" to make tally marks, and math word sentences. Persimmons themselves can be considered a part of Japanese culture in general, but introducing them around the time of the persimmon harvest gives readers a sense of Japan's distinct four seasons. Though many countries use tally marks of some kind, using a Chinese character (*kanji*) to do so is uniquely Japanese. The concept of math word sentences, too, is found outside of Japan, but the textbook tells the story of how the term "math word sentence" (*kotoba no shiki*) took hold in Japan and became a part of its mathematics education culture.

Translate using terms appropriate to each grade level

A final characteristic of the textbook is that the terms used evolve and change with advancing grade level.

How to translate the term *kasa*, for example, was a topic of ongoing discussion. We felt that it wouldn't have been appropriate to use the words "capacity" or "volume" until the Japanese terms *yōseki* and *taiseki* were introduced later in the series, so we decided to go with the word "amount". When it came to grammatical tense, we restricted it to present tense wherever possible in grades one and two, adopting all tenses once again in the grade three textbook. In this way, by restricting the use of special terms and expressions until a certain point in the series, we hoped to recreate a key feature of Japanese textbooks, which progress in a way that is sensitive to the developmental stages of children.

In sum, we eagerly await the judgment of readers themselves as to whether a textbook prepared according to these guidelines is truly successful as translation.



Profile

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Baba, Takuya (2007) "Consideration of Mathematics Education in the Society and the Times with Multiplicity of Values" 89(10), pp. 20-27.

Some Background for my involvement

Robert Reys [Supervisors of Fun with MATH]

Introduction

Over two decades ago, my family and I spent a year in Japan. Our son attended a neighborhood elementary school, and our daughter attended a local preschool in Tsukuba. Neither child spoke Japanese, and we quickly learned that their teachers could not speak English. However, several mothers (volunteers at the school) spoke English and were very helpful to our children throughout the year. As parents, we were pleased our children were accepted in the schools and successfully adapted to their new school environment. We visited their schools often throughout the year. In addition to the regular classroom learning activities, we watched the children wash windows, sweep halls, serve their own lunches, and clean up after eating lunch in their classroom. We were pleased to see the pride that the children exhibited in doing these daily chores. The teachers always made us feel welcome during our school visits.

We returned to the United States with some direct knowledge of Japanese schools. Since returning home, we have continued to work with different Japanese mathematics educators. We have returned to Japan for professional meetings, and have hosted many different Japanese mathematics educators for short and long visits at the University of Missouri.

I was a co-author of a K-8 mathematics textbook series widely used in the United States, and have a long time interest in school mathematics curriculum. When I was asked to review the English translation of a recent elementary Japanese mathematics textbook series, I gladly accepted the invitation. This request provided an opportunity to review a complete mathematics textbook series and help produce a resource that would be available to English readers throughout the world who would like to learn about a Japanese elementary mathematics curriculum.

About the translation process

Mathematics is a universal language. This is reflected by the pictures, art, models, tables and graphs that provide an excellent representation of the mathematical nature of the lessons in textbooks. The visual images of the original Japanese edition remain identical in the English translation. Only the wording has changed. My knowledge of Japanese is minimal at best. So in every case, Japanese mathematics educators and editors made the initial translation from Japanese to English. I was sent the resulting copy in English and asked to review the English translation for accuracy and clarity. The bottom line question I used to guide my review, was "Does it make sense?" If so, I offered no changes. If not, then I suggested some word changes that I felt clarified the meaning or reflected the English language that is normally used. I read and reread the English narrative provided on every page of each of the books in each of the grades. I offered corrections when appropriate, but overall my comments and suggested corrections were minimal. Japanese translators examined my feedback. Then there was often further communication to clarify or make sure that my comments and suggestions were clearly understood. This exchange was another reminder of the level of attention being given to every phrase or utterance reflected in the textbook series.

Some things to keep in mind

- Japanese textbooks are physically small in size. They have fewer pages than elementary mathematics textbooks in many countries, such as the United States.
- Extensive sets of exercises are NOT included in the textbook. Some practice is provided, but extended opportunities for practice are not reflected in the main textbook pages (Japanese students can purchase other workbooks to provide additional practice, if necessary).

- Functional art and models play a prominent role in every lesson. Every picture or piece of art is used to either stimulate problem solving or support instruction.
- Tables and charts appear in some lessons at every grade. This information is used in many different ways, but consistently provides opportunities for students to engage in problem solving and promote higher order thinking skills.
- Some models are introduced in one grade and then elaborated and built on to in later grades. For example, the number line model is introduced early, extended and developed as the complexity of the mathematical tasks increase.
- Attention is given to mathematical relationships. For example, there is a focus on inverse operations as addition and subtraction are introduced and developed, as well as when multiplication and division are introduced and developed.
- Be watchful for the difference in the order of the multiplicand and multiplier generally found in Japanese textbooks as compared with textbooks in other countries, including the U.S. For example, (x times y) in the U.S. is generally modeled as x groups with y things in each group. In Japan, x times y is modeled as y groups with x in each group. So while the end result is the same, the physical models are different and this difference is reflected throughout the series.
- Notice that some Japanese terms are used and remain in the English translation. These appear prominently with regard to number names. For example, the number 100,000 represents a "hundred thousand" in English, but means "ten ten-thousands (*man*)" in Japanese. Japanese terms can be spotted quickly, because they are always placed in italics.
- Unit fractions provide the initial introduction to and development of fractions, and unit fractions are used to promote thinking about fractions. For example, students are encouraged to think of ¾ as being 3 of ¼.

Finally, an examination of the series will illustrate how the Japanese societal and cultural environment is naturally integrated into lessons throughout the series. For example, contexts for mathematics may focus on homes, stores, neighborhoods, towns, or prefectures. Regardless of the focus, it is always clear that Japan is the centerpiece. So an examination of this elementary mathematics textbook series illustrates how mathematics content is organized and developed in a coherent and logically developed manner.

Closing

In closing, it has been an intellectually rewarding opportunity for me to help in the development of the English version of this textbook. I have learned much in the process, but my contribution to the final product is very small. My hope is that the English version of this elementary textbook series will be useful to people in countries throughout the world—including, children, classroom teachers, principals, school board members, parents, and anyone interested in curriculum development.

Profile

Robert Reys

Robert Reys is a Curators' Professor of Mathematics Education at the University of Missouri, working with both undergraduate and graduate students. He has served as major advisor to more than 30 PhD students in mathematics education. He is the author or co-author of over 200 articles in refereed journals and more than 30 books. He has been a Fulbright Research Lecturer at the University of Guanajuato (Mexico) and the University of Gothenborg (Sweden). In 2008 he received the prestigious Lifetime Achievement Award from the National Council of Teachers of Mathematics.

The first mathematics class

This is the first page that first-graders learn in a math class in Japanese elementary school.
How do teachers give a lesson for 45 minutes using this page with no words?
(In Japanese elementary schools, each period lasts for 45 minutes.)

Fun with MATH1
p4～p5

These two pages are supposed to be taught in two periods. Students learn the part enclosed with red lines in the first period.

As shown below, Japanese teachers make a detailed lesson plan in advance.

a sample lesson plan

Objective

Have children match groups of objects one-to-one as a way of comparing how many there are.

Evaluation criteria

Interest Children take an interest in numerical quantities.
Thinking Children can compare numbers of objects by drawing or using semi-concrete objects.
Skill Children understand quantity as the number of objects in a group, and can compare group size using one-to-one matching.
Knowledge Children can use the one-to-one comparison method to figure out relative quantity.

Lesson overview

It is thought that most children count the number of two different items in groups to determine which item has more. When introducing them to math, however, it is important to make them compare the items by matching them one-to-one and visually confirming the difference in number—instead of simply comparing them based on abstract numerals. Find ways to make children devise their own one-to-one matching methods whenever possible.

You can use the scenes presented in the textbook to ask questions like "Which frog will sit on which lily pad?" or "Which honeybee will get which dandelion?" This will get them to compare the frogs and lily pads or honeybees and dandelions one-to-one.

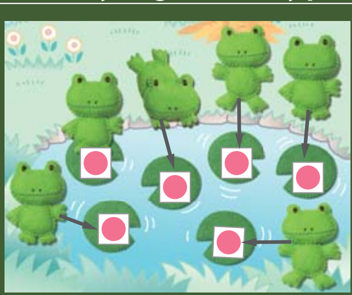
First, get children to find a way to express one-to-one comparisons in the textbook by drawing lines or circling to indicate which frog sits on which lily pad. You can replace the frogs with numbered blocks or similar objects that children can manipulate so that they understand the value of using semi-concrete objects. If possible, cut out pictures of frogs and attach magnets to them so that children can move them around on the board. This will further motivate them to use semi-concrete learning tools. Then have them use the same problem-solving methods they learned with the frogs and lily pads to work with the honeybees and dandelions.

Required materials

Teacher: Pictures to put on the board, numbered blocks for demonstrating
Students: Colored pencils, numbered blocks

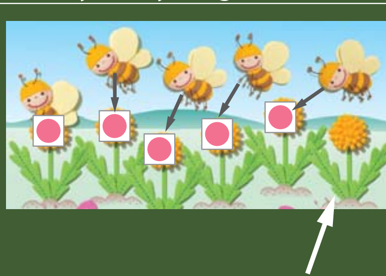
On the board

Can every frog sit on a lily pad?



Exactly enough = same amount

Can every honeybee get a dandelion?



Too many = 1 dandelion left over

Sample lesson

Learning stage and questions	Children's activity and response	Remarks, evaluation, methods (→)
Have fun continuing the story from the last lesson.	•Have students talk about what a rabbit saw when it looked outside the door. ○A squirrel was hiding in a cherry tree. ○A river was flowing by. ○There were frogs. Six frogs. ○One of the frogs was sitting on a lily pad.	•Get students to remember the previous lesson—the scene where the rabbit playing hide-and-seek with his playmates opened one of the doors. •Thoroughly check children's awareness. **Interest** Get students to have fun looking for different objects. (observation, expression)
Determining relative amount using one-to-one comparisons. •Can every frog sit on a lily pad?	•(Counting) If there are an equal number of frogs and lily pads, every frog can sit on one. •Have children draw in their textbooks to check whether every frog can really sit. ○Draw a line connecting each frog to a lily pad. ○Draw an arrow showing where each frog will sit. ○Circle pairs of frogs and lily pads. •Use numbered blocks to represent the frogs. Move each blog on a lily pad to compare the number of each one. •Get children to think about what it means that there are no frogs without lily pads and no extra lily pads left over.	•Do not criticize children for counting to compare numbers. Praise them for their ability to count. •Make sure children know that only one frog can sit on each lily pad. Instruct them to show clearly which frog goes on which lily pad. •Show the entire class some of the ways that children expressed one-to-one matching. Praise their efforts. •Get children to see that every frog can have a lily pad because there is exactly the same number of each. **Skill** Children can express one-to-one relationships between the frogs and lily pads. (observation) •Get children to see how handy semi-concrete objects are when they are used to show one-to-one comparisons of objects drawn on paper (which cannot be moved). **Skill** Children are able to express the one-to-one relationships between the frogs and lily pads. (observation) **Knowledge** Children see that because there is not an excess or lack of frogs or lily pads, the number of each is the same. (expression)
•Can every honeybee get a dandelion?	•Have children use what they have already learned to compare the number of honeybees and dandelions. Get them to think about what it means that there is a dandelion left without a honeybee on it.	•Have children draw in their textbooks or use the numbered blocks to find the answer on their own. **Skill** Children are able to express the one-to-one relationships between the honeybees and dandelions. (observation) **Knowledge** Children see that because there is one dandelion left without a honeybee, there is one more dandelion than there are honeybees.

Introduction of Japanese mathematics culture

Ex. About the character “正”

This page introduces expressions and teaching materials peculiar to Japan.
Each book has footnotes explaining Japanese words and phrases found there.

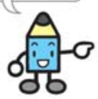
1 Making tables

1 Let’s make a table to sort out the number of people that want to play the sports on the previous page.

A Writing the Chinese character “正” is an easy way to count the number of people.
Sort out the number of people by filling in “正”.

Dodge ball	
Line soccer	
Hand baseball	
Port ball	

B Convert the “正” into numerals and sort out the numbers in the table on the right.



Selected sports (Class 1)

Sport	Number of people
Dodge ball	
Line soccer	
Hand baseball	
Port ball	
Port ball	

C What sport did the most people want to play?

2 Use the same method to search the sports you want to play in your class and make a table for sorting out the results.

59

Fun with MATH 3B p59

<Sample Footnote>

＊5 p.59 The character 正

In Japan, the Chinese character 正 is commonly used to count objects, much like the tally mark system typically used in English-speaking countries. As the callout on p. 59 explains, the character 正 is written with five strokes, so one 正 can be used to represent 5, two to represent 10, three to represent 15, and so on.
The standard meaning of the character is “true” or “correct”, making it the perfect tool to inspire students to “count properly”.

An excerpt from the sample lesson plan

Objective

Have children address the task of making tables and graphs to organize data using everyday scenes, such as sporting events. Get them to use the character 正 to represent data and organize it in a table.

Evaluation criteria

Interest Children work to sort and organize data based on an objective.
Thinking Children are able to come up with sorting and organization methods that do not leave out or double-count data items.
Skill Children are able to use the character 正 to express data quantities and organize that information in a table.
Knowledge Children understand how to skillfully organize and summarize information in a table so that it is easy to understand.

Sample lesson

<table>
<tr><th>Learning stage and questions</th><th>Children's activity and response</th><th>Remarks, evaluation, methods (→)</th></tr>
<tr>
<td>Have children look at an illustration and think of a way to organize cards.

•Which item looks like it has the most?
•How can you make the information easy to understand?</td>
<td>•Guess which item has the most.
•Think about how to organize the information.
"I bet it would be easy to understand if we made a table like we did in second grade."
"If we made a graph using dots (●), we could understand it right away."</td>
<td>•Display the illustrations and get children interested in the topic.
•Ask them how they might organize the data so that it would be easy to see which sport was the most popular. Get them to see that a table or graph would be good to use so that they grasp the point of the lesson.
Interest Children work to sort and organize data based on an objective. (observation, expression)</td>
</tr>
<tr>
<td>Make a table so that it is easy to see how many people want to play each sport.

•Have children try to organize the numbers in a table so that they are easy to understand.</td>
<td>•Use the 正 character to find out the number of people in each category.
<table>
<tr><td>Dodge ball</td><td>正</td></tr>
<tr><td>Line soccer</td><td></td></tr>
<tr><td>Hand base</td><td></td></tr>
<tr><td>Port ball</td><td></td></tr>
</table>
•Use numerals to organize the number of people in each category and write them in the table.
Preferred sports (Class 1, number of people).
<table>
<tr><th>Sport</th><th>Number of people</th></tr>
<tr><td>Dodge ball</td><td></td></tr>
<tr><td>Line soccer</td><td></td></tr>
<tr><td>Hand base</td><td></td></tr>
<tr><td>Port ball</td><td></td></tr>
<tr><td>Total</td><td></td></tr>
</table>
•Calculate the total number of people and make sure it matches the number of data items.</td>
<td>Thinking Children are able to come up with sorting and organization methods that do not leave out or double-count data items. (note-taking, expression)
Skill Children are able to use the character 正 to express data quantities and organize that information in a table. (note-taking)
→Have children place a check or similar mark on the original data items so that they pay attention to avoid missing or double-counting items. Advise them to use the 正 character in their table to find out the number of each item.
•Get children to see that using the 正 character allows them to count data items in groups of five.
→If the totals and number of data items don't match, ask children to consider the problem from two angles: either their total calculation is incorrect, or they missed or double-counted an item when they were sorting and organizing the data.</td>
</tr>
</table>

※These sports are typically taught during physical education class in elementary school.

Note: **Line Soccer** is a simplified form of soccer. In addition to the regular field players, the team assigns a "line man" to kick the ball to their team members in the field when it goes outside the touch-line. No goal or goalkeeper is used, so teams earn points when the ball passes beyond the goal line.

Note: **Hand Baseball** is a simplified form of baseball. The batter hits a soft rubber ball with their palms instead of bat, and the other team catches the ball with bare hands instead of using gloves.

Note: **Port Ball** is a simplified form of basketball, and teams earn points when a child standing on a stool marking the goal (the "goal man") successfully catches the ball in his or her hands.

Selection of translations based on grade progression

About the expression “*kasa* (capacity/volume)”

We are careful about the developmental stage of the children, and use descriptions appropriate for their math learning level.

Fun with MATH 1 p69

An excerpt from the sample lesson plan

Objective

Have children compare capacity. Get them to see that they can compare the capacity of containers by filling one with water and then pouring it into another or by using a third container.

Evaluation criteria

Interest Children get interested in comparing capacity and want to try doing it in different ways.

Thinking Children are able to think of ways to compare capacity when it cannot be compared directly.

Skill Children are able to compare capacity by transferring liquid from one bottle to another.

Knowledge Children understand how to compare capacity using indirect comparisons.

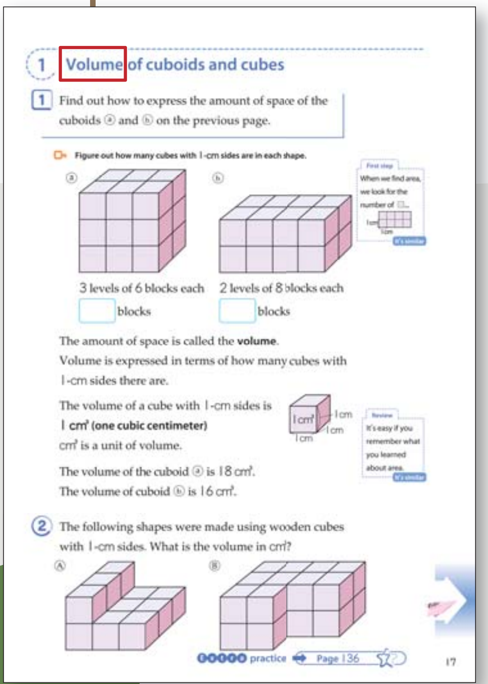
Sample lesson

Learning stage and questions	Children’s activity and response	Remarks, evaluation, methods (→)
Comparing the capacity of liquid in two bottles. ・Which bottle holds more?	・Think about which bottle holds more.  “The bottles have different shapes, so we can’t compare them just by looking at them.” ・Discuss ways to compare them. “We could transfer the water from one bottle to another.” “We could transfer the water into another bottle.” “We could compare the water using cups.”	・While children are comparing the shape and size of two different bottles, introduce the word “capacity” as the amount that each can hold. Stress that the lesson will look at capacity and focus on “comparing capacity”. ・Have children guess which bottle holds more. **Interest** Children get interested in comparing capacity and want to try doing in different ways. (observation, expression) →Remind children of when they compared lengths. Because they can’t directly overlap capacity, let them know that they need to think of a different way to compare the capacity of water. **Skill** Children are able to compare capacity by transferring liquid from one bottle to another. (observation)

<Sample Footnote>

＊5 p.69, 142 Graduated terminology

In Japan, fifth graders learn to quantify the volume of rectangular boxes, cubes, and other shapes, as well as derive the relevant formulas. Prior to that, the word kasa (the common word for bulk or capacity) is used rather than the mathematical term taiseki to refer to volume. Japanese educators feel that particular importance should be placed on this transition between the terms kasa and taiseki, which gives students an introduction to mathematical terms by way of everyday concepts and expressions. Japanese mathematics education is characterized by a host of similar examples of graduated terminology, including hirosa (the common word for area or spaciousness) and menseki (mathematical area), chigai (difference) and sa (mathematical difference, as in subtraction), and shiki (equation or formula) and tōshiki (equality).



Fun with MATH 5A
p17

An excerpt from the sample lesson plan

Objective

Have children remember what they learned about area as they compare the size of cuboids. Get them to see the importance of having a basic unit to express capacity and understand the concept of volume. Teach them about cubic centimeters (1 cm^3).

Evaluation criteria

Interest Using their study of area as an analogy, children see the importance of having a basic unit to express capacity. Find ways to capture their interest.

Knowledge Children see that they can find the volume of any shape if they count the number of 1-cm^3 cubes.

Skill Children are able to express volume as the number of 1-cm^3 cubes.

Knowledge Children learn that 1 cm^3 is the basic unit of volume.

Sample lesson

Learning stage and questions	Children's activity and response	Remarks, evaluation, methods (→)
Find the volume of a cuboid by figuring out the number of cubes with 1-cm sides. •How many cubes with 1-cm sides are there in cuboids (a) and (b)? **Teach the meaning of volume and 1 cm^3.**	•Look at the figures or use actual 1-cm^3 cube building blocks to figure out how many 1-cm^3 cubes there are. "We can't see the back of the shape." "I think we should just count each level." "(a) has three levels of six cubes, so that's 18. (b) has two levels of eight cubes, so that's 16." •Teach the meaning of "volume" and the "unit of volume (1 cm^3)". •Get children to understand that the volume of cuboid (a) can be expressed as 18 cm^3, and the volume of (b) can be expressed as 16 cm^3.	•Use area as an analogy, reminding children that they tiled 1-cm^2 squares to find it. Get them to see that they can figure out how many cubes with 1-cm sides there are and then ask them questions. →Have children actually count the number of 1-cm^3 cubes in either (1) the sketch on p.16, (2) the sketch with the grid on p. 17, or (3) building blocks. •Pass out 1-cm^3 blocks and have children actually work with them so that they learn the unit of volume (1 cm^3) and get a sense for how much it is. **Knowledge** Children learn that the number of 1-cm^3 cubes can be used to express the volume of a cuboid. (observation, expression)

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