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A Comparative Study of Teaching Critical Thinking in Japanese and Iranian Third-Grade Mathematics Textbooks

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ABSTRACT

The purpose of the research was to investigate how the authors of third-grade mathematics textbooks in Iran and Japan pay attention to the teaching of critical thinking components. This is a comparative research using "different social systems, different educational outputs" strategy for the selection of the sample. Also, data collection and analysis methods were documentary and integrated content analysis respectively. The first finding indicated that the topics of mathematics education in the primary schools of both countries are almost the same. The second finding shows that special attention has been paid to the use of different methods to solve problems in Japanese math textbooks; so that in most cases pupils are asked not to use only one solution. Another finding reveals the difference between the two countries in terms of the use of practical and concrete issues for children; in a way that in the Japanese math textbook- unlike in Iran -, all the lessons and problems are related to the daily life of the students. Another difference is related to the way of summarizing the topics of each chapter. In the Japanese math textbook, students are taught how to take notes on what they have learned and use them for further learning. Also, at the end of each chapter, questions are designed related to the entire topic, which is similar to the chapter review section in the Iranian math book. However, in the Japanese math book, next to each question, the book guides students to which page to refer to - if they do not know the answer to that question – and read the related material again.

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1. Introduction

Considering that the cultivation of thoughtful people is the main goal of education and without it, the development of society is not conceivable, the basis of most of the educational reforms- in different societies- is also focused on this issue and it is directing the educational system towards thought-oriented education (Lu, 2011). According to the definition of UNESCO (2020), "critical thinking is a process that involves asking appropriate questions, gathering and creatively sorting through relevant information, relating new information to existing knowledge, re-examining beliefs and assumptions, reasoning logically, and drawing reliable and trustworthy conclusions". Critical thinking is not an innate ability, although some students may be naturally curious people, they need to be educated to systematically analyze things and be fair and open-minded in their search for knowledge (Mulnix, 2012). Also, due to the important role of critical thought in the success of students, many researchers believe that it should be included in the school curriculum.

Students learning are greatly affected by the educational materials and content. Research shows that school textbooks still play an important and decisive role in the education process (Horsley & Sikorová, 2015; Stará et al., 2017). School textbooks are like a bridge connecting the intended curriculum to the implemented curriculum - at the classroom level. In particular, in countries with a centralized education system, school textbooks largely determine the way teachers are trained to teach subjects such as critical thought (Dehghani, 2016). Observing the problems that many Iranian primary school students have in the process of learning critical thinking, prompted the present researchers to examine the method of teaching it in the textbooks of other countries.

In comparative research, Zamani et al. (2020) by examining the components of critical thinking in the first-grade science textbooks of Iran and Russia showed that the frequency of the components of critical thinking in order from the highest to the lowest are as followed: The components of engaging, questioning, combining, reasoning, analyzing, judging and evaluating. The frequency of these components was different in Iranian and Russian books. Yaftian & Abbasi (2019) compared the structure of mathematics books for first to fourth grade in Iran and Japan and revealed that the difference in these books is in the review and summary at the end of the chapters of the Japanese books in addition to the process of presenting lessons and the number of pages; while their similarity is in the use of various concepts and games and entertainment. Azadi & Shirvani Shiri (2018) showed that compared to Iran, Japanese first-grade math book makes students think more. Also, the content of the Iranian school textbook is beyond the mental capacity of the learners and confuses the learners and as a result their poor performance in the educational

process. Karimi (2018) by examining the effect of Farsi Books for Grades 4, 5 & 6 on developing critical thinking skills, showed that the most and least attention is paid to analysis skills and the skill of using critical vocabulary in the fourth grade, respectively. In the fifth grade, the most and least attention is paid to analysis skills and communication skills, respectively; while in grade 6, no attention is paid to the teaching of critical thinking, so the structure of the book should be revised. Qanadian (2017) compared the third-grade math textbooks of Iran and Singapore and found that Iran's and Singapore's math books have three common goals, and in one of these goals i.e., problem-solving, there are differences in the way the goal is expressed. While the authors of Singapore school textbooks put a lot of emphasis on the drawing strategy, in Iran there are eight strategies: pattern making, pattern finding, drawing, symbolizing, converting a problem into sub-problems, solving a simpler problem, guessing and experimenting, and eliminating undesirable modes to solve problems presented. Shakeri (2017) by examining the books “Gifts of Heaven” and Hatami Manjezi (2017) by examining the books of social studies in primary schools using Lippmann's components of critical thinking, showed that the frequency of the components of critical thinking in these books is not balanced and proportional; for example, the questioning component has been discussed more than other components. Danaei Zarchi (2016) compared Iran's 4th-grade mathematics curriculum with five pioneering countries in the TIMSS 2015 international exam (Singapore, Hong Kong, South Korea, Taiwan, and Japan). He found that in terms of attention to goals such as teaching numbers and calculations, there is a similarity between Iran's textbooks and these countries, but it is different in terms of attention to problem-solving skills. Nazari (2016) by analyzing the content of the book "Thought & Research" of the sixth grade and Pirfirouzjaei (2015) by examining the critical thinking components in Farsi books of primary school using Shannon's entropy method, showed that these books paid less attention to critical thinking and creativity than other components of thinking. Ezadi, Reihani & Ahmadi (2014) by comparing the methods of teaching addition and subtraction in the third-grade math school textbooks of Iran, Japan, and the USA found out that the contents of the math textbooks in these countries are respectively based on the conceptualization of addition and subtraction operations, the discovery of the methods by the students and increasing their ability to problem-solving. Kochaki (2014) by examining science books in Iran’s elementary schools showed that science books focused mostly on low cognitive levels and did not provide the conditions for critical thinking. Farajzadeh (2013) examined Grades 1, 2 & 3 math textbooks of Iran's primary schools and indicated that the amount of attention paid to the components of critical thinking was low, although, in Grade 3, more attention was paid to the components of Lippmann's critical thinking.

Researchers from other countries have also shown interest in examining textbooks from the aspect of teaching critical thinking. For example, Mai et al., (2019) investigated Malaysian first to third-grade science books in terms of thinking skills and showed that the "evaluation" and "bias detection" thinking skills are not paid attention to in these books, and the most emphasized is based on learning the "attributing", "analyzing", "grouping and classifying" and "sorting" skills. Solihati & Hikmat, (2018) by examining critical thinking in the second secondary language teaching textbooks in Indonesia based on the Ilyas framework showed that the components of critical thinking have not been given proper attention. The examination of critical thinking in the social studies book of the fourth primary school in Turkey showed that the authors paid the most attention to teaching the components of openness, correctness, communication, and adequacy and less attention to the components of depth and accuracy (Aybek & Aslan, 2016). Ilyas (2015) in the study of English language teaching school textbooks in Indonesia from the perspective of critical thinking by combining 21 theories, prepared a framework for analyzing these components and showed that only 15% of the content of language teaching textbooks is dedicated to critical thinking.

In Iran, a significant number of researchers have investigated the components of critical thinking in Iranian textbooks, and most of the research has been based on the application of Lippmann's components of critical thinking. Searching in English sources also shows that attention to the analysis of the content of textbooks in other countries is less, which may be due to the decentralized educational system and the non-book-centered nature of these countries. Although much research has been conducted in Iran and other countries in the field of comparative education and curriculum of the countries, the number of researches in the field of comparative study of textbooks is limited. In the current study, Japan was chosen because, Firstly, the students of this country obtained high ranks in international tests, and secondly, like Iran, it has a centralized educational system and textbooks are very important in the educational system. The main goal of this research is a comparative study of critical thinking education in the Grade 3 mathematics textbooks of Japan and Iran, and the sub-goals are:

- Examining and describing third-grade mathematics textbooks in Japan and Iran from the point of view of teaching critical thinking
- Investigating and identifying the similarities and differences between the third-grade mathematics textbooks of Japan and Iran from the point of view of teaching critical thinking.

2. Research Method

The current research is a comparative study and the population includes all countries of the world. The sample selection (Japan and Iran) were selected using the strategy of "different social systems, different educational output". The method of data collection was documentary through primary sources (Grade 3 math school textbooks) and secondary sources (searching in Iranian and international information databases). The method of data analysis was “cumulative content analysis” which is one of the integrated content analysis methods in which the researcher first counts concepts and sentences and then instead of focusing on statistical analysis, he turns his attention to the use of words in each specific context (Tabrizi, 2011, 134-133). Therefore, in the present study, questions related to critical thought in school textbooks were analyzed and compared qualitatively. The goal of the researchers was to examine critical thought in the first to the third grade of primary school, but findings of some research showed that less attention was paid to this type of thought in Grades 1 & 2 (Pirfirouzjaei, 2015; Farajzadeh, 2013). In addition, as the researchers were not familiar with the Japanese language, the English version of the math textbook was selected and used for comparison with the Iranian version.

Analytical classification is needed to identify the components of critical thought in school textbooks using the content analysis approach (Krippendorff, 2018). Categories are used to distinguish activities related and unrelated to critical thinking. In this research, for content analysis, the critical thinking framework of Ilyas (2015) was used as the basis for analytical categories. In his doctoral dissertation, Ilyas (2015) proposed a conceptual framework for examining critical thinking in school textbooks. This framework is the result of examining, evaluating, and synthesizing 21 theories related to critical thinking. In this research, this tool was translated and used for the first time in Iran. Based on Ilyas's framework, components of critical thinking were extracted from two selected books (Grade 3 math in Japan and Iran), which include 8 components and 17 sub-components. Components include; Clarification, Assumption, Reason, Perspective, Alternative, Question, Prediction, and Summary. Coding was done based on the first letter of English words. Table 1 shows the sub-components related to each component. Also, for a better understanding of the components, examples of questions related to each sub-component are given.

Table 1: Components of critical thought extracted in Ilyas Framework

Component	Code	Sub-component	Example
Clarification	C1	Explaining the meaning	What is meant by...? What does the phrase ... mean?
	C2	Explaining for clarity	Explain more. Explain how...
	C3	Giving an example to make it clearer	Give an example for...
Assumption	As1	Making assumptions and explaining assumptions	What is your assumption? Do you suppose that...? What did he assume? Why would anyone make this assumption?
	As2	Estimating	Do you guess that... Do you think that approximately... Estimate that...
Reason	R1	Arguing and providing evidence	Give reasons for your answer. Do you think that...? Why? What is your reason for saying this? Provide evidence to support your answer. According to the pictures, do you think that...?
	R2	Questioning of reasons and evidence	What is the evidence provided by the author of the text? What are the reasons given by the author? Are these reasons enough? Can this evidence be doubted? Why?
Perspective	Pe1	Questioning from the person's point of view	Do you think...? What do you think about...? Do you agree that...? Why? Why didn't you choose this view instead?
	Pe2	Questioning different views and opinions	Can anyone see from this point of view? Compare reviews. Summarize/categorize comments.
Alternative	Al1	Offering different ways or other options	What are the ways for…? Is there any other way? What is the alternative solution? Can you suggest a better solution?
	Al2	Exploring different ways	Which of the ways is better? Explore and compare different ways. Categorize the different ways.
Question	Q1	Asking a question	Ask a question for... Ask a similar question.

	Q2	Questioning from the question	Why is this question important? Are these questions appropriate? Is the answer to the question easy or difficult? Why?
Prediction	Pr1	Questioning of what happens after this	What do you think will happen? How will it affect the future?
	Pr2	Question of consequences	What is the result? What would happen if we did ...?
Summary	S1	Summarizing and concluding	Summarize the text/story. Summarize your opinion. Summarize and compare the information in a table/graph.
	S2	Conclusion	What do you conclude from the story? What is the conclusion of the text?

To analyze the content of textbooks, after the classes were determined, the unit of analysis was determined. In this research, the unit of analysis is the theme, which includes all the questions in each section of the math textbooks. A question refers to all items that ask students to do something, such as "answer," "look," "compare," "write," "show," "discuss," "do.", etc. Also, various types of texts or images, including descriptions, tables, diagram, and photos, were used to pose questions. In multi-part questions, different parts of the question were considered separate questions. After identifying the unit of analysis (topics), coding was done. In this research, all the questions and works that were stated in the textbooks were analyzed. Then, considering which question leads students to thinking skills, that question was attributed to one component of critical thinking.

3. Findings

The findings of the research are presented in two parts: First, a description and analysis of primary school Grade 3 math textbooks; Second, a comparison of similarities and differences.

Part 1: Description and analysis of the third-grade math textbook of primary schools in Iran and Japan

1. Iran's third grade math textbook

This book has 151 pages and includes 8 chapters with topics such as patterns, four-digit numbers, fractional numbers, multiplication and division, perimeter and area, addition and subtraction, statistics and probability, and multiplication of numbers. The content of Iran's math

textbook (text, pictures, questions) was analyzed according to Ilyas's framework and the frequency and percentage of themes related to each component of critical thinking were calculated (Table 2).

Table 2: Frequency and percentage of critical thinking components in Iran math books

Critical thinking components	Frequency	Percentage
Clarification	48	6.7
Assumption	37	5.2
Reason	36	5.0
Perspective	14	2.0
Alternative	14	2.0
Question	4	0.6
Prediction	3	0.4
Summary	18	2.5
Sum of components	174	24.3
All textbook questions	716	100

The content analysis of the math textbook of Iran showed that a total of 24.3% of its themes are related to critical thinking components. Also, the authors of the book have paid more attention to the teaching of the "clarification of meaning" component than other critical thinking components. Table 3 shows an example of questions related to each component.

Table 3: Examples of questions related to each critical thinking component in Iran's third grade math textbook

Component	Sub-component	Example
Clarification	Explaining the meaning	_
	Explaining for clarity	Explain what the number machine does. (p. 22)
	Giving an example to make it clearer	Write two sentences in which the word "probability" or "chance" is used. (p. 130)
Assumption	Making assumptions and explaining assumptions	_
	Estimating	How many centimeters is the thickness of this paper package approximately? (p. 33)
Reason	Arguing and providing evidence	Why do both clocks show the same time? Explain. (p. 22)
	Questioning of reasons and evidence	_
Perspective	Questioning from the person's point of view	Which solution do you prefer? (p. 24)
	Questioning different	_

	views and opinions	
Alternative	Offering different ways or other options	In how many ways can we write the sum of two numbers whose sum is 12? (p. 26)
	Exploring different ways	Compare your figures with those of your friends. (p. 58)
Question	Asking a question	Ask your friend some questions like the ones above. (p. 17)
	Questioning from the question	–
Prediction	Questioning what happens after this	If we spin the spinner 10 more times, how much of the graph do you predict will be green? (p. 125)
	Question of consequences	–
Summary	Summarizing and concluding	Do this test 10 times and complete the table below. (p. 121)
	Conclusion	What results do you get from the multiplications and answers? (p. 137)

2. Japanese third-grade math book

The name of the Japanese school textbook in English is "Mathematics International Grade 3", which has been published three times by Tokyo Shoseki Publications (Fujii & Iitaka, 2012). This book includes two volumes A (123 pages) and B (120 pages) and has 19 units in total. The most important topics of these units are as followed: multiplication, how to find time and elapsed time, division, circles & spheres, addition & subtraction algorithms, mental calculation, division with remainders, the structure of large numbers, multiplication algorithm (1), division with large numbers, how to measure the length of long objects, decimal numbers, triangles, fractions, math sentences, multiplication algorithms (2), bar graphs and tables, measurement units of weight and how to measure, and abacus.

Table 4: Frequency and percentage of critical thinking components in Japanese math textbooks

Critical thinking components	Frequency	Percentage
Clarification	50	7.2
Assumption	20	2.9
Reason	41	5.9
Perspective	6	0.9
Alternative	62	8.9
Question	5	0.7
Prediction	0	0.0
Summary	23	3.3
Sum of components	207	29.9
All textbook questions	693	100

The content analysis of the Japanese math textbook (text, pictures, questions) according to the Ilyas framework and calculating the frequency and percentage of themes -related to each critical thinking component- indicated that a total of 29.9% of the themes of this book are dedicated to teaching critical thinking components. Also, the authors paid more attention to the components of "presenting and examining different ways" and "clarifying the meaning" than other components. Table 5 shows examples of questions related to each component.

Table 5: Examples of questions related to each component in the Japanese mathematics book

Component	Sub-component	Example
Clarification	Explaining the meaning	_
	Explaining for clarity	Explain how the calculation on the right was done. (p. B20)
	Giving an example to make it clearer	_
Assumption	Making assumptions and explaining assumptions	_
	Estimating	Try to estimate the length first before you measure. (p. B5)
Reason	Arguing and providing evidence	Find the hidden numbers. Explain the reason too. (p. A7)
	Questioning of reasons and evidence	_
Perspective	Questioning from the person's point of view	Which is easier to calculate? (p. A102)
	Questioning different	See what your friends wrote in their Reflections?

	views and opinions	(p. B29)
Alternative	Offering different ways or other options	In what ways can you calculate 300 × 5? (p. A92)
	Exploring different ways	Talk about the similarities between these three ideas. (p. A94)
Question	Asking a question	Make up word problems involving direct distance and traveling distance using the picture map. (p. B8)
	Questioning from the question	–
Prediction	Questioning what happens after this	–
	Question of consequences	–
Summary	Summarizing and concluding	What did you learn in today's lesson? (p. A13)
	Conclusion	–

Part 2: Comparison of Iranian and Japanese third-grade math textbooks

A. Similarities

The first similarity between Iranian and Japanese math textbooks is in the titles of the chapters. The common topics that are taught in both Japanese and Iranian third-grade math books are multiplication, division, circle, addition and subtraction algorithm, division with remainders, multiplication algorithm, measuring the length of long objects, triangles, fractions, math sentences, bar graphs and tables, units of measurement of mass, and method of measurement.

The second similarity between the two textbooks is the method of teaching, which is similar in some cases in both books. For example, both books use folding and dividing strips of paper to teach the concept of fractions; or to teach the concept of division, a problem of "dividing into equal groups" is used and division is done with the help of figures, and then the relationship between multiplication and division is expressed. Based on the description given in the first part of the findings, it was found that 29.9% of the total themes in the Japanese book and 24.3% of the total themes in the Iranian book are related to the components of critical thinking. Therefore, the third similarity is in the amount dedicated to the components of critical thinking, which indicates that the authors in both countries have paid attention to the components of critical thinking. Also, the similarity in the amount of attention paid to the four components of Clarification, Reasons, Question and Summary - according to graph 1 and the percentage of frequencies given in the first part of the findings- is more visible.

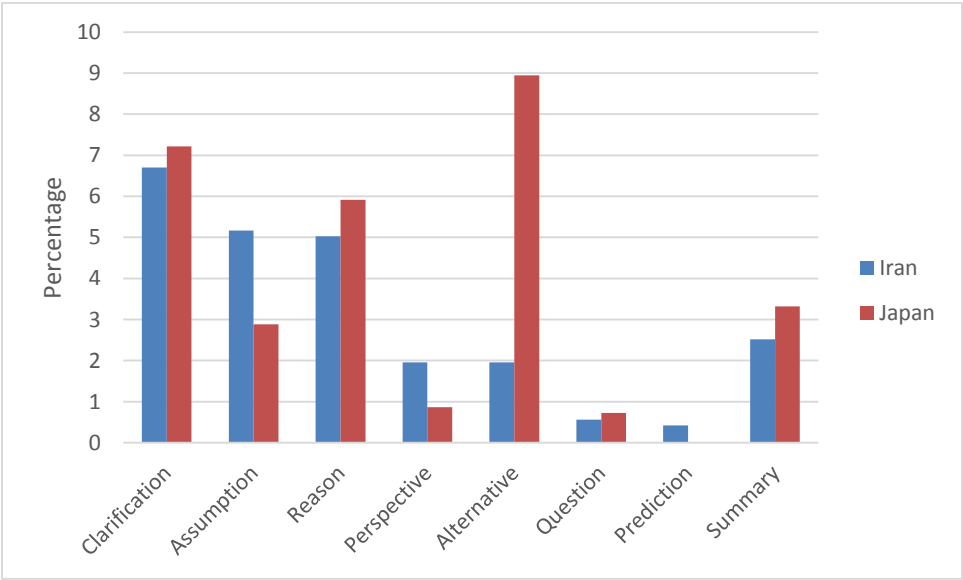


Figure 1: Comparison of the percentage of critical thinking components in Iranian and Japanese math textbooks

B. Differences

As mentioned before, the educational topics in the math textbooks of Iran and Japan are common with each other in many cases, although there are differences in some cases (Table 6).

Table 6: Different items in the educational chapters of Iranian and Japanese mathematics textbooks

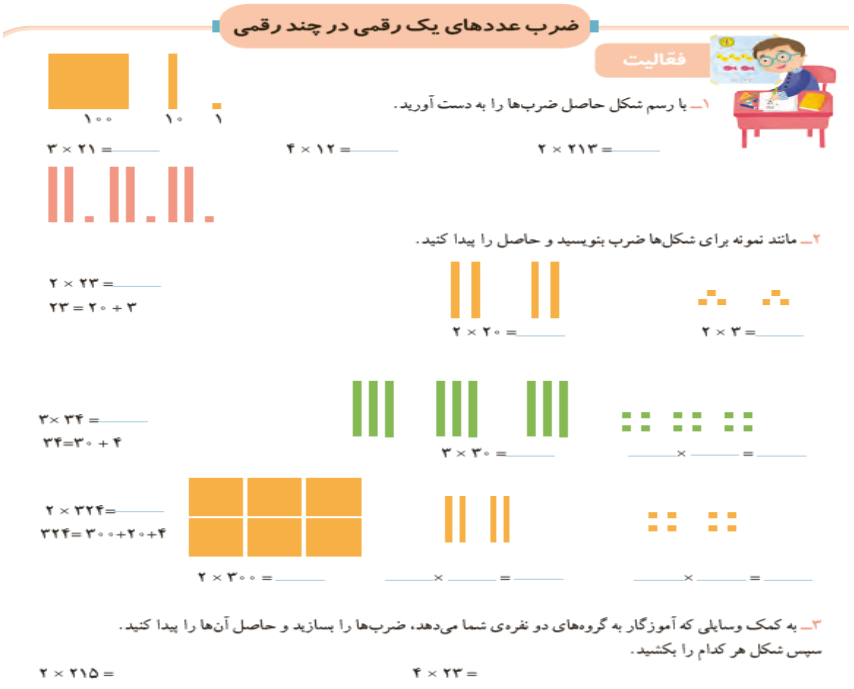
Chapter	Unit in the third grade Japanese math book	Iranian math book
1	How to find time and elapsed time	Fourth grade
2	Spheres	Sixth grade
3	Mental calculations	Are not mentioned directly in any of Iran's math books
4	Numbers greater than 10,000	Fourth grade
5	Division of large numbers	Fourth grade
6	Decimal numbers	Fourth grade
7	Abacus	Are not mentioned in any of Iran's math books

According to Table 6, it is clear that the first difference is related to the educational topics, in such a way that some of the topics of the third-grade math textbook in Japan are taught in Grade 4 and 6 math books of Iran. Also, the two subjects of "mental calculations", and "abacus" - which are taught to students in Grade 3 of primary school in Japan-, are not included in any of the math textbooks of Iran's primary schools.

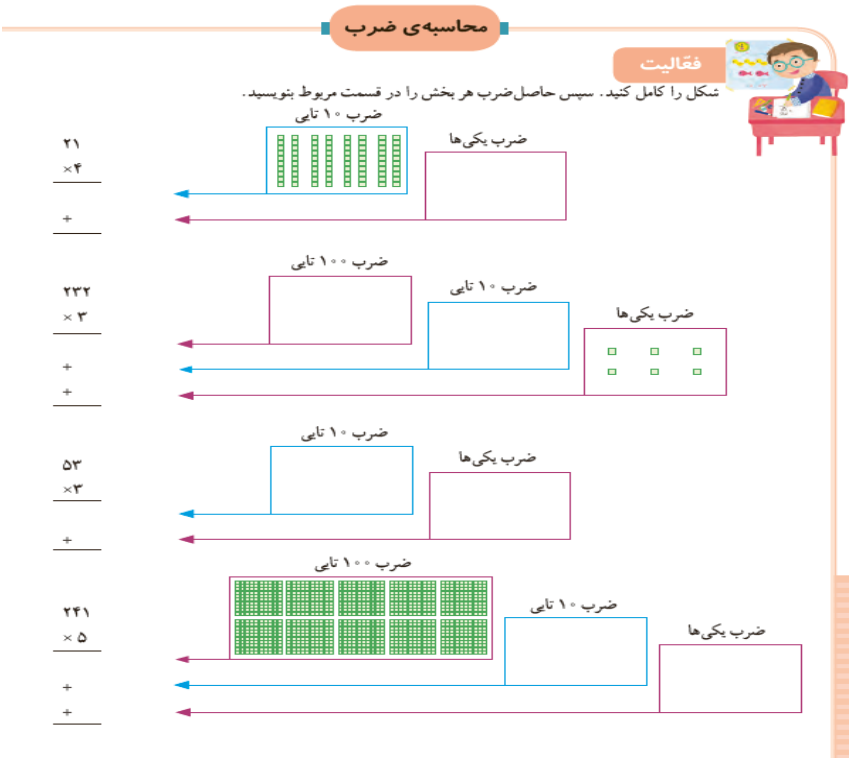
As seen in the similarities section, the amount of attention paid to the four components of critical thinking in the two mathematics books of Iran and Japan was almost the same, but according to the percentages in Tables 4 and 2 - which are given in the first part of the findings and figure 1 -, the amount of attention to the other four components of critical thinking is different. Therefore, the second difference between the two books is the amount of attention paid to the components of Assumption, Alternative, and Prediction. The main difference between the two books is in the component of Alternative, - which in the Japanese math book has 62 themes (8.9%) and in Iran has only 14 themes (2%). Also, the component of Prediction was seen only in 3 of the themes (text, image, questions) of the Iranian math textbook, while this component was not seen in the Japanese book.

The third difference can be assigned to the way of explaining some components of critical thinking. As it was found, the greatest amount of difference belongs to the component of Alternative. In the following, by presenting an example of teaching "multiplication", we will compare how this component is dealt with in two books.

In the Iranian math book, for the first time, students encounter the multiplication of "one-digit numbers by multi-digit numbers". Learners are asked to multiply multi-digit numbers by one digit by drawing a figure or the base ten blocks and get the product (Picture 1). Students are then given a practice page to find the answer to "multiplication" using the figure. On page 142 of the book, the multiplication of multi-digit numbers in one digit is taught (picture 2).



Picture 1: Learning to multiply "multi-digit numbers" by "one-digit" numbers in the Iranian math book (page 139)

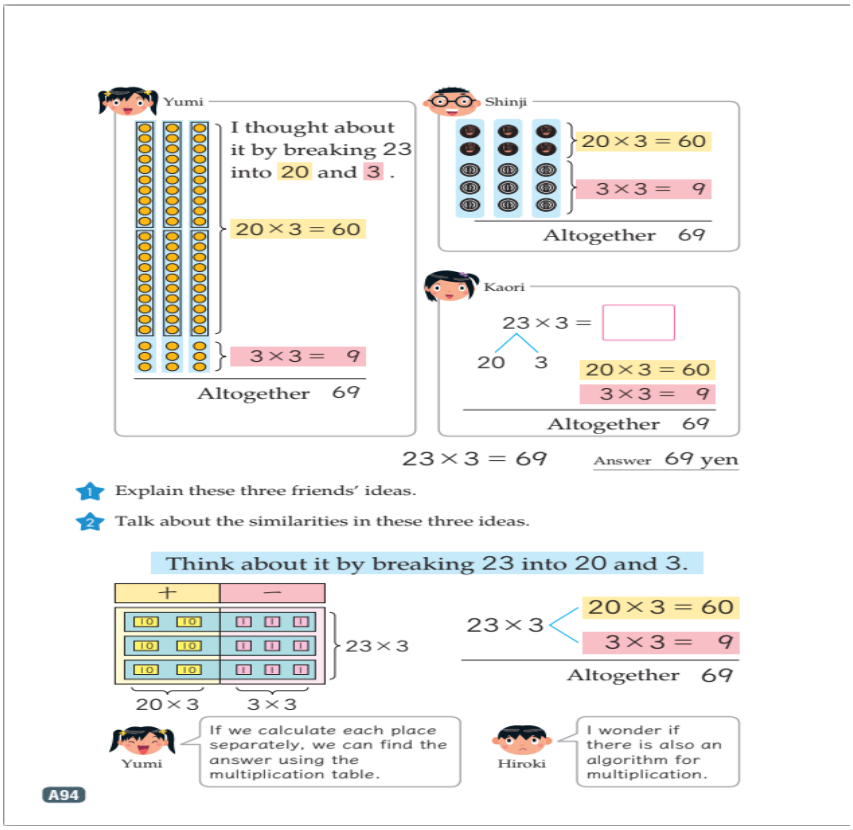


Picture 2: Learning how to multiply multi-digit numbers by single-digit numbers in the Iranian math book (page 142)

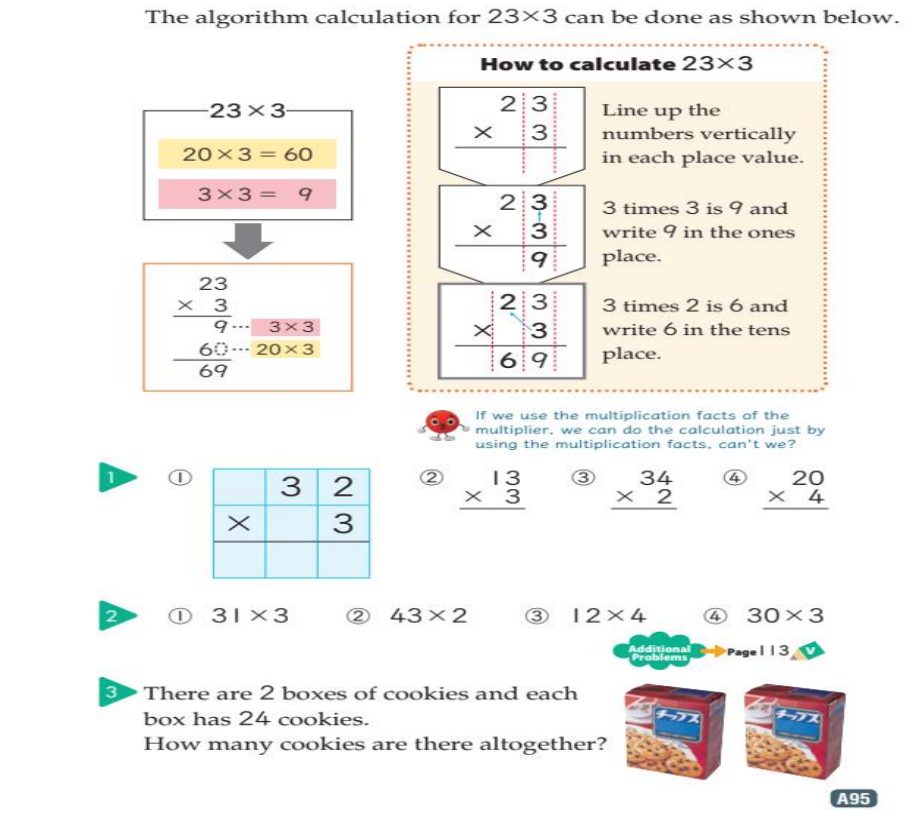
Therefore, in the Iranian math textbook, before starting the activity, the student is not encouraged to think about different solutions; and the number of questions that encourage students to think with their classmates is very limited. Students are more likely to check the solutions provided by the authors of the book than the solutions provided by their classmates. To teach the operation of "multiplication" in the third-grade Japanese math textbook, first, the students were asked about the methods of obtaining the product of the number "12" multiplied by the number "4". Then they are asked to calculate the answer of multiplication using a mathematical figure or expression and show their calculation method so that their classmates will also understand what their solution is. In the following, four methods for obtaining the answer of multiplying the number 12 by the number 4 are shown, and students should explain and compare these methods. In addition to the solutions in the book, the pupils were asked to check the solutions of their classmates and discuss them with each other. Chapter 9 of the Japanese math textbook is specifically devoted to multiplying multi-digit numbers by a single digit. The teaching of this topic begins with a practical example:

> “We are buying 3 sheets of colored construction paper that cost 23 yen each. How much will it cost?"

Students write the question in mathematical terms and think about how to get the answer. Then, three solutions for calculating multiplication are presented and students are asked to explain each of the solutions and discuss their similarities with each other (Figure 3).



Picture 3: Learning how to multiply multi-digit numbers by a single digit in the Japanese math textbook (page A94)



Picture 4: Learning how to multiply multi-digit numbers in a single digit in the Japanese math textbook (page A95)

Finally, after going through the above steps, learners are taught how to multiply single-digit numbers by multi-digit ones. As seen, in the Japanese math textbook to teach multiplication of multi-digit numbers in one digit, students are encouraged to think and present different solutions during several stages and finally, multiplication is taught to them.

The fourth difference between the two math textbooks of Iran and Japan is related to the way of using practical questions. In the Iranian version, the connection of mathematics with life is often seen in problem-solving; but it is noteworthy that some of the questions are not practical for children and they do not face them in their daily life. In picture 5, two examples of the questions of the statistics chapter - which are not useful for children - can be seen. It asks the students to show the number of sheep and milk bottles using a bar graph.

کار در کلاس

۱ــ تعداد گوسفندان چند روستا به صورت تقریبی در جدول زیر مشخّص شده است.

نام روستا	علی آباد	حسن آباد	وکیل آباد	محمود آباد
تعداد گوسفندان	۲۰۰۰	۴۰۰۰	۸۰۰۰	۶۰۰۰

اگر بخواهید این اطّلاعات را در نمودار نشان دهید، چه نوع نموداری را انتخاب می‌کنید؟ پس از انتخاب نمودار، آن را رسم کنید.
کار خود را با دوستانتان مقایسه کنید.

تمرین

۱ــ مغازه‌داری تعداد بطری‌های شیر را که در روزهای مختلف هفته فروخته، در جدول زیر ثبت کرده است.

روز	شنبه	یکشنبه	دوشنبه	سه‌شنبه	چهارشنبه	پنجشنبه
تعداد بطری‌ها	۳۰	۲۵	۳۵	۱۵	۳۰	۴۰

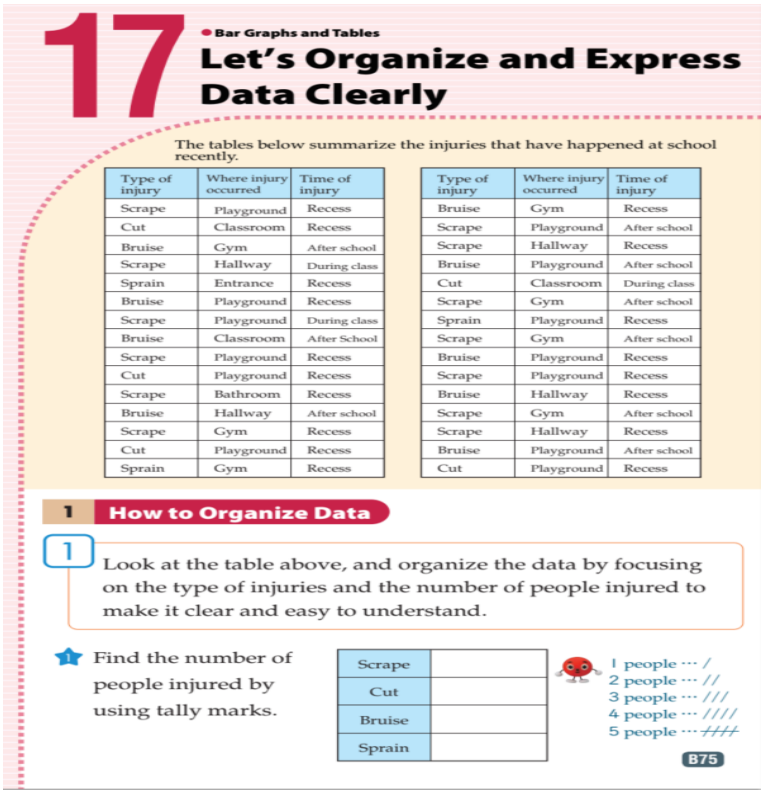
اطّلاعات جدول را در یک نمودار ستونی قرار دهید.
این مغازه‌دار در چه روزی کمترین مقدار شیر را فروخته است؟
چرا روز پنجشنبه فروش شیر بیشتر بوده است؟
به نظر شما، بهتر است این مغازه‌دار هر روز چند بطری شیر
برای فروش بیاورد؟ _____ چرا؟ _____

۱۳۰

Picture 5: Two examples of questions from the Iranian math textbook (pages 128 - 130)

In the Japanese math textbook, the problems are designed in such a way that they are practical for children (and not adults) and students face them in their daily lives. An example of starting a book chapter with problem-solving in a Japanese math textbook is the statistics chapter. In the beginning pages of this chapter, the types of injuries (scratches, cuts, bruises, sprains), and the place and time when the students were injured are presented in a table - as an introduction to teaching the topic of data organization. Then the students are asked to count the number of injured people and write in two separate tables for different types of injuries and different places using the table in the book (Picture 6).

In the next section, using the same question, the application of the column chart will be taught. Through the questions that are asked to the students, they are taught that when a column chart is used, it is possible to compare the data at a quick glance (Picture 7). Finally, in the last part of the chapter, data organization is discussed using tables. In three separate tables, the most common types of injuries related to the months of November, October, and January are shown and students are asked to summarize these three tables in one table to get a better understanding of the total information (Picture 8).



17

Bar Graphs and Tables

Let's Organize and Express Data Clearly

The tables below summarize the injuries that have happened at school recently.

Type of injury	Where injury occurred	Time of injury
Scrape	Playground	Recess
Cut	Classroom	Recess
Bruise	Gym	After school
Scrape	Hallway	During class
Sprain	Entrance	Recess
Bruise	Playground	Recess
Scrape	Playground	During class
Bruise	Classroom	After School
Scrape	Playground	Recess
Cut	Playground	Recess
Scrape	Bathroom	Recess
Bruise	Hallway	After school
Scrape	Gym	Recess
Cut	Playground	Recess
Sprain	Gym	Recess

Type of injury	Where injury occurred	Time of injury
Bruise	Gym	Recess
Scrape	Playground	After school
Scrape	Hallway	Recess
Bruise	Playground	After school
Cut	Classroom	During class
Scrape	Gym	After school
Sprain	Playground	Recess
Scrape	Gym	After school
Bruise	Playground	Recess
Scrape	Playground	Recess
Bruise	Hallway	Recess
Scrape	Gym	After school
Scrape	Hallway	Recess
Bruise	Playground	After school
Cut	Playground	Recess

1 How to Organize Data

1 Look at the table above, and organize the data by focusing on the type of injuries and the number of people injured to make it clear and easy to understand.

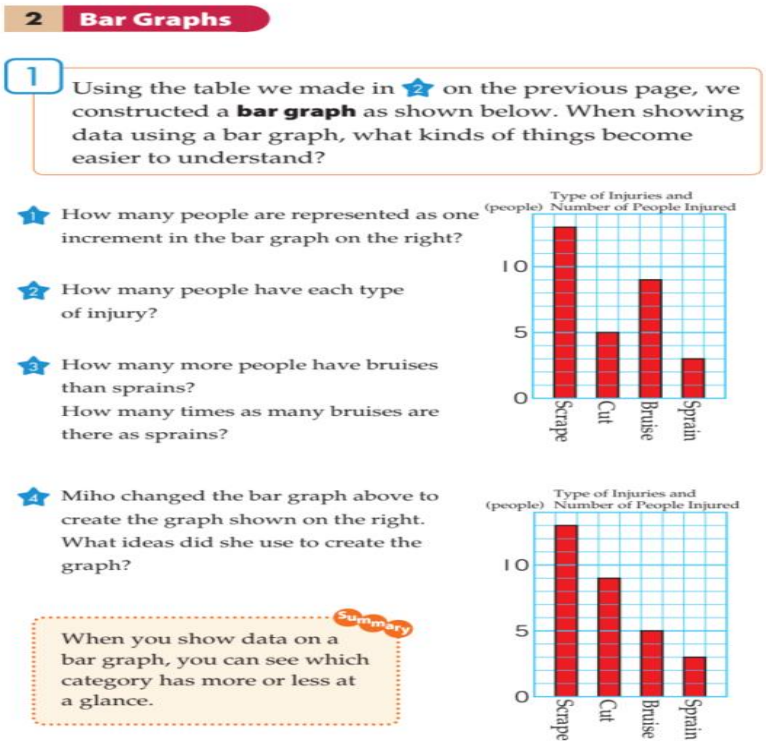
Find the number of people injured by using tally marks.

Scrape	
Cut	
Bruise	
Sprain	

1 people ··· /
2 people ··· //
3 people ··· ///
4 people ··· ////
5 people ··· ////

B75

Picture 6: Table of types, location and time of injuries as an introduction to teaching the subject of data organization (page B75)



2 Bar Graphs

1 Using the table we made in **2** on the previous page, we constructed a **bar graph** as shown below. When showing data using a bar graph, what kinds of things become easier to understand?

1 How many people are represented as one increment in the bar graph on the right?

2 How many people have each type of injury?

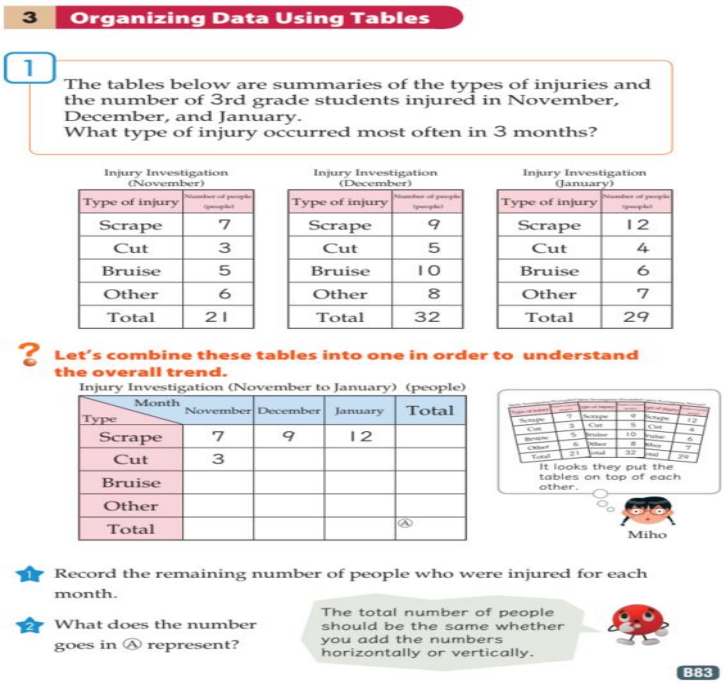
3 How many more people have bruises than sprains?
How many times as many bruises are there as sprains?

4 Miho changed the bar graph above to create the graph shown on the right. What ideas did she use to create the graph?

Summary

When you show data on a bar graph, you can see which category has more or less at a glance.

Picture 7: Teaching the use of column charts (page B77)



3 Organizing Data Using Tables

1 The tables below are summaries of the types of injuries and the number of 3rd grade students injured in November, December, and January.
What type of injury occurred most often in 3 months?

Injury Investigation (November)

Type of injury	Number of people (people)
Scrape	7
Cut	3
Bruise	5
Other	6
Total	21

Injury Investigation (December)

Type of injury	Number of people (people)
Scrape	9
Cut	5
Bruise	10
Other	8
Total	32

Injury Investigation (January)

Type of injury	Number of people (people)
Scrape	12
Cut	4
Bruise	6
Other	7
Total	29

Let's combine these tables into one in order to understand the overall trend.

Injury Investigation (November to January) (people)

Type \ Month	November	December	January	Total
Scrape	7	9	12	
Cut	3			
Bruise				
Other				
Total				Ⓐ

1 Record the remaining number of people who were injured for each month.

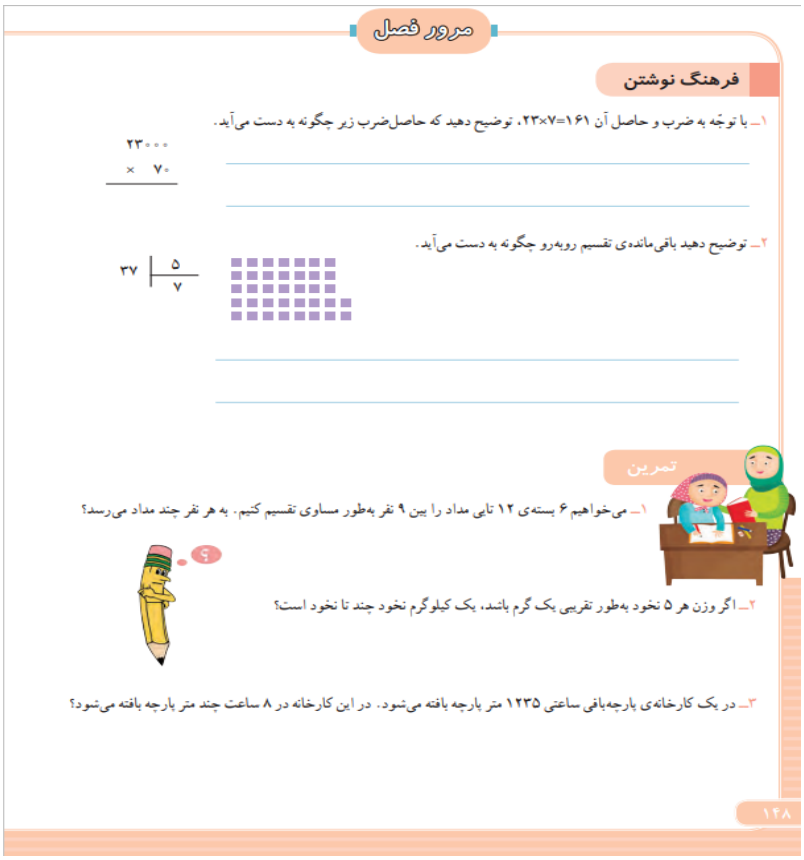
2 What does the number goes in Ⓐ represent?

The total number of people should be the same whether you add the numbers horizontally or vertically.

B83

Picture 8: Data organization training (page B83)

The fifth difference between the Iranian and Japanese math textbooks is related to the summary at the end of each lesson. As shown in the similarities section, the amount of attention paid to the Summary component in Iranian and Japanese math books is almost the same, but the way this component is presented is different. In Iran's version, at the end of each chapter, there are two pages namely "Chapter Review" which includes the "Writing" and "Practice" sections. In the "Writing" section, students review the important topics of the chapter by answering some questions. These questions are not comprehensive and do not include all topics of the chapter, and students are not taught how to answer them. For this reason, it is difficult for students to answer these questions (Picture 9).


مرور فصل

فرهنگ نوشتن

۱ــ با توجّه به ضرب و حاصل آن ۱۶۱=۷×۲۳، توضیح دهید که حاصل‌ضرب زیر چگونه به دست می‌آید.

۲۳۰۰۰
× ۷۰

۲ــ توضیح دهید باقی‌مانده‌ی تقسیم رویه‌رو چگونه به دست می‌آید.

۳۷ | ۵
۷

تمرین

۱ــ می‌خواهیم ۶ بسته‌ی ۱۲ تایی مداد را بین ۹ نفر به‌طور مساوی تقسیم کنیم. به هر نفر چند مداد می‌رسد؟

۲ــ اگر وزن هر ۵ نخود به‌طور تقریبی یک گرم باشد، یک کیلوگرم نخود چند تا نخود است؟

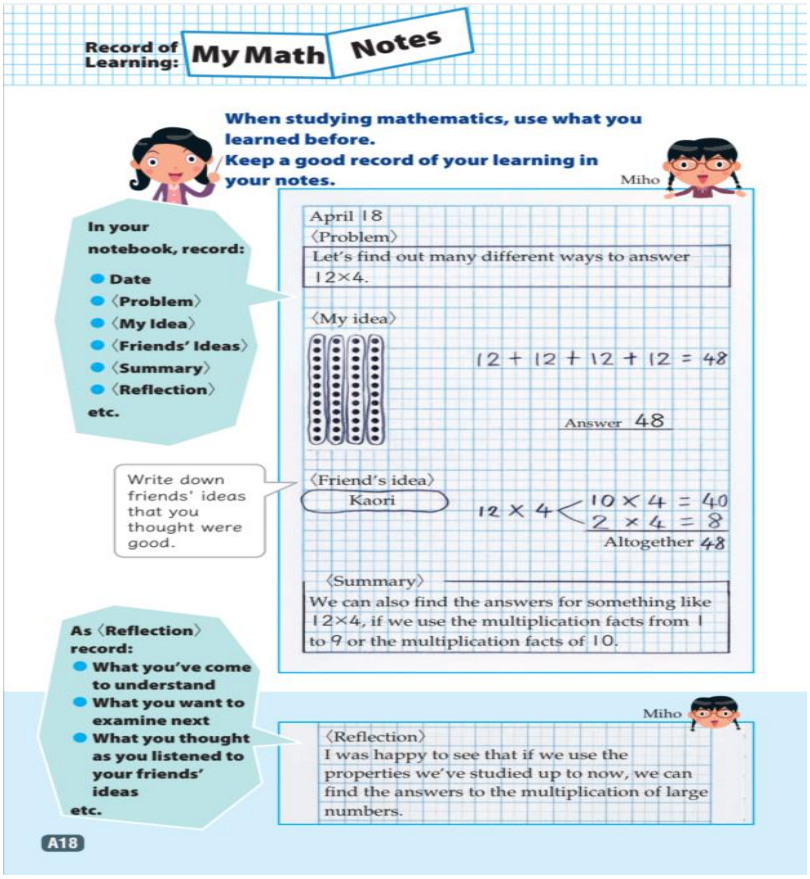
۳ــ در یک کارخانه‌ی پارچه‌بافی ساعتی ۱۲۳۵ متر پارچه بافته می‌شود. در این کارخانه در ۸ ساعت چند متر پارچه بافته می‌شود؟

۱۴۸

Picture 9: An example of a chapter overview of Iran book (P. 148)

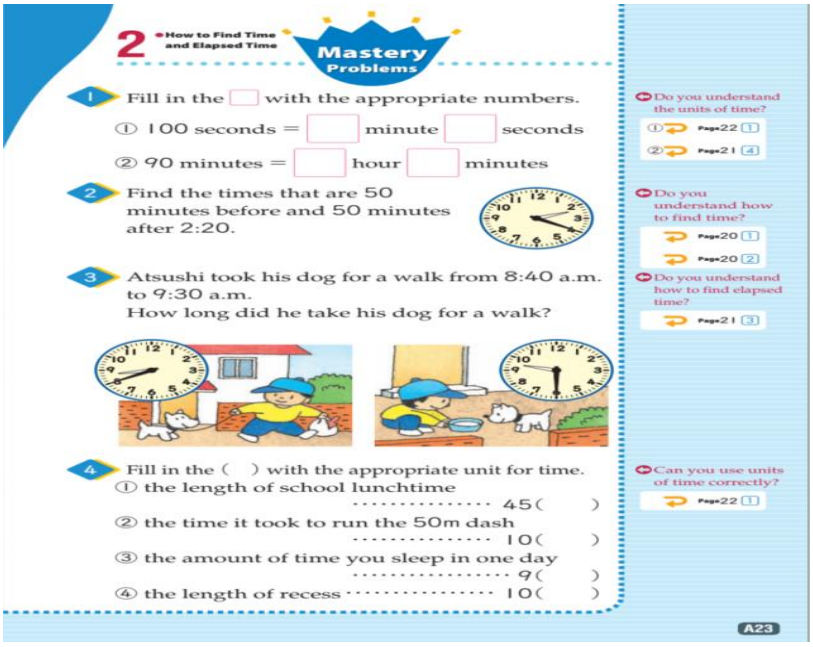
In the Japanese math textbook, students are told to take notes on what they learn and use their previous learning. The note includes the date, the problem, the student's idea, the classmates' idea,

a summary, and a reflection. In the classmates' idea section, the ideas that other children suggest are recorded. In the feedback section, the student writes what she/he understood, what she/he wants to examine next, and what she/he thought of when listening to her/his friends' ideas (Figure 10).



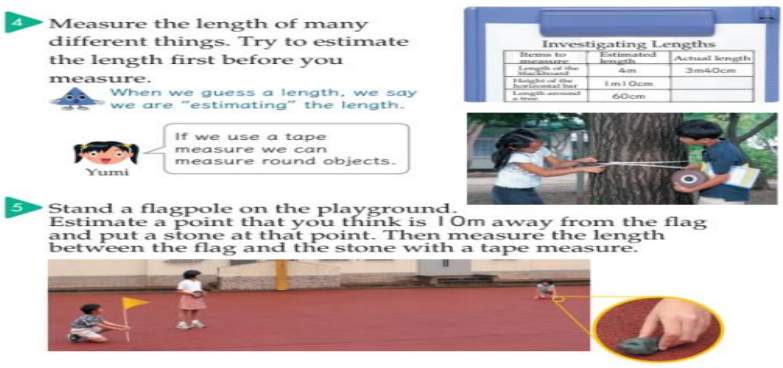
Picture 10: Teaching note-taking in the Japanese math textbook (pages A18 and A19)

Also, in the Japanese math textbook, questions related to the topics are designed at the end of each chapter, similar to that in the chapter review section in the Iranian math version. The remarkable point in the Japanese math textbook is that in the end-of-chapter questions, next to each question, pupils are guided to which page of the book to refer to if they do not know the answer to the question to read the related material again. In this way, the responsibility of learning is placed on the students themselves, so that by using the questions, they can measure their level of learning and if they have not understood something well, they will know how to fix their problems (Picture 11).

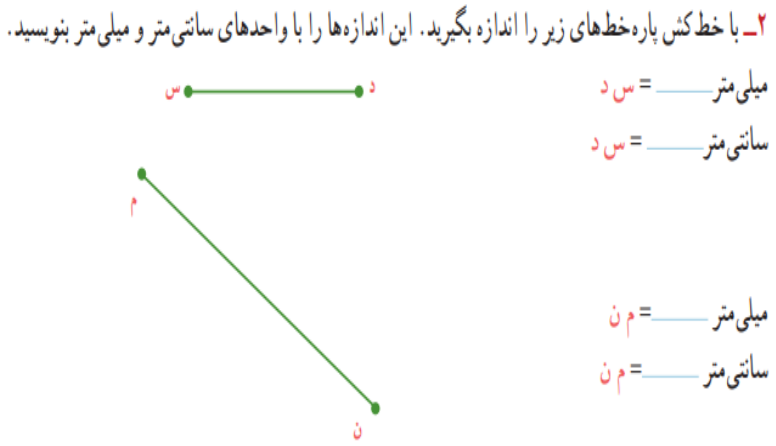


Picture 11: End-of-chapter questions and student reference to previous pages in the Japanese math textbook (page A23)

The sixth difference between Iranian and Japanese math textbooks is related to estimation before measurement. As mentioned in the first difference between the two books, one of the differences is related to the amount of attention to the assumption component. The number of questions related to this component in the Iranian math textbook (37) is more than in the Japanese math version (20); but in the Japanese math book, when teaching the subject of "measurement of mass, length and time", students are asked to estimate before measuring; while in the Iranian math book, students are not asked to estimate before measuring (Picture 12 & 13).

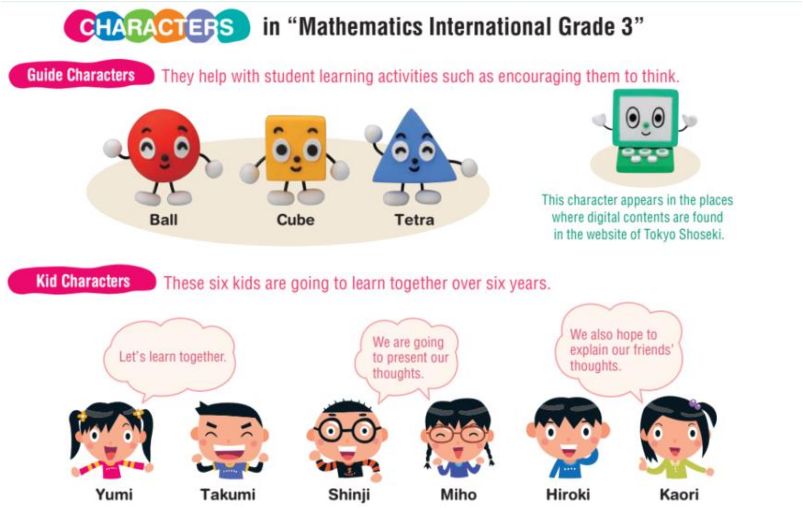


Picture 12: Estimation in Japanese math book (page B5)

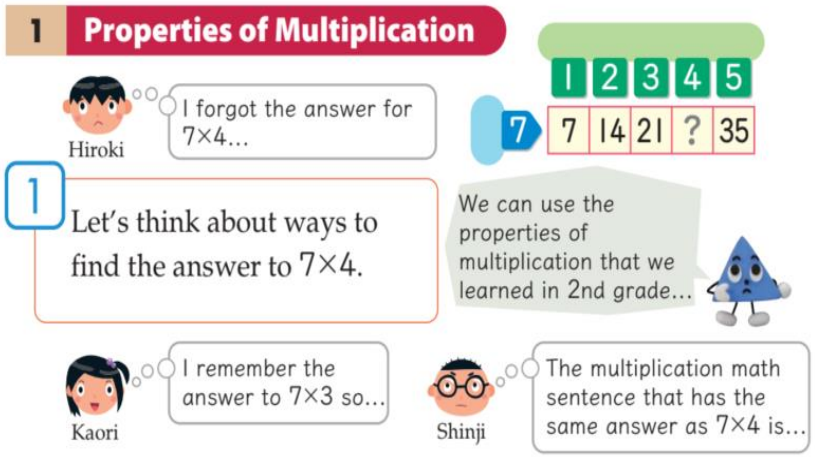


Picture 13: Measurement in Iranian math book (page 83)

The seventh difference between Iranian and Japanese math textbooks is related to the pictures in the book. Regardless of the high quality and attractiveness of Japanese textbook images, authors use them to convey concepts, and in fact, part of the learning process takes place through pictures. At the beginning of the Japanese math textbook, two types of characters are introduced: the characters of geometric shapes that play the role of guides, and the child characters who think, comment, ask questions and answer in different parts of the book. These characters can be seen in all math textbooks from Grades 1 to 6. It is interesting that the faces of the child characters in the higher grades have changed a little and they seem to have grown up. In fact, these characters accompany the students and help them learn better (picture 14). For example, picture no. 15 is related to the beginning of the first chapter and is an introduction to the teaching of the "properties of multiplication" concept, which teaches the subject of multiplication through the dialogue of the characters.



Picture 14: Introduction of Japanese math book characters



Picture 15: Role of characters in the Japanese math textbook in teaching the concept of multiplication

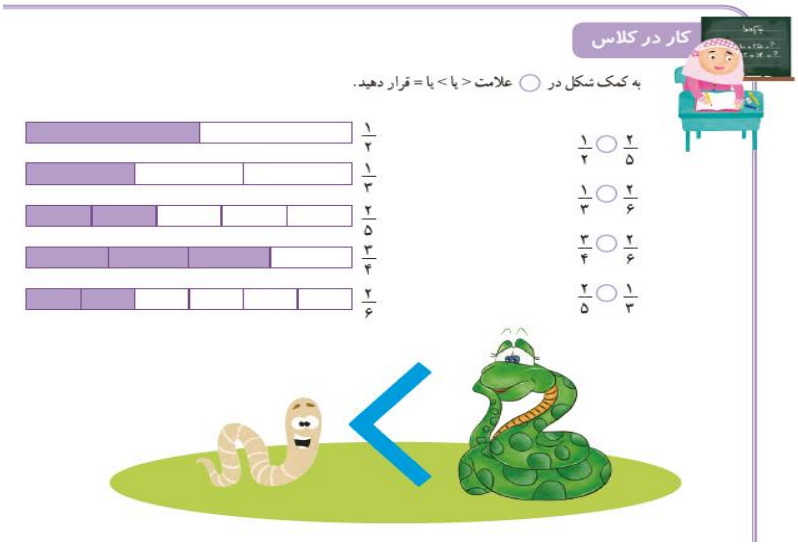
In the Iranian math textbook, there are images such as pencil, ladybug, worm, etc. that are constant but seem to have been randomly placed in different sections of the book, and it is not the case that, for example, the image of a pencil is used only in the problem-solving section (Table 7). Therefore, the images are graphically different and there is no uniformity in the selection of images; and, there are only two images that are placed in related sections: An owl holding a ruler next to ruler questions and a boy holding a calculator next to a question that needs a calculator. Other pictures are randomly placed in the white parts of the book pages and there is no connection between the picture and the question next to it.

Table 7: Use of fixed images in Iranian math textbooks

Unrelated Pictures	
Picture	Sections
Pencil 1 	Work in class Problem-Solving Complete Practice Activity
Pencil 2 	Count and Say Practice Complete Problem-Solving Writing Estimate
Ladybug 	Practice Writing Be Creative Activity Work in class Problem-Solving Reading
Worm 	Engagement and Puzzle Practice Work in class Complete Problem-Solving
Frog 	Work in class Activity Problem-Solving Practice
Boy 	Work in class Activity Problem-Solving
Snake 	Work in class Problem-Solving

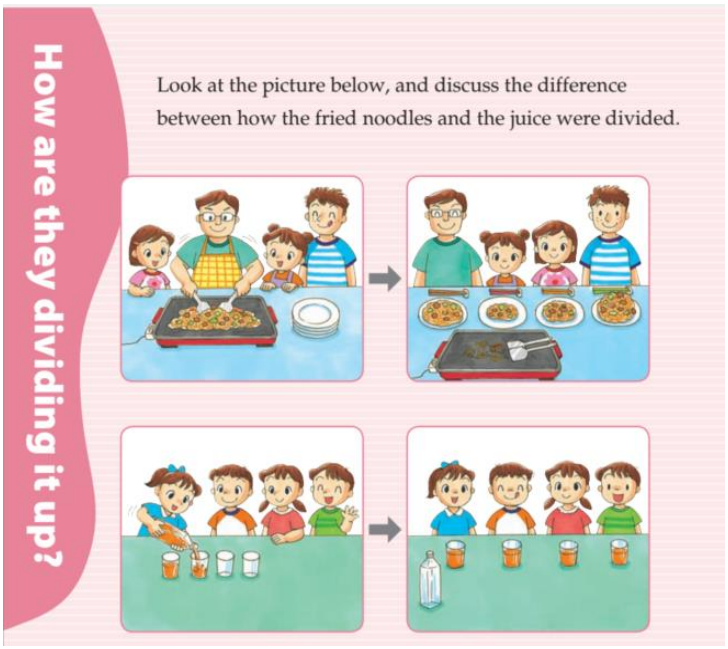
Unrelated Pictures	
Picture	Sections
Boy with Calculator 	Work in class (calculator) Exercise (calculator) Activity (calculator) Work with a calculator
Owl 	Practice (measurement) Problem solving (measurement) Discover (measuring) Practice (working with a ruler)

Also, in many cases in the Iranian math textbook, the picture is completely decorative, and removing it does not harm the teaching. For example, Figure no. 16 compares two fractions using the figure. In the image below, the size of the snake and the worm are compared. In other words, the question on this page is about comparing fractions with equal units, but the picture shows the size comparison of "one" snake and "one" worm, both of which are "one" but with unequal units.



Picture 16: Using unrelated pictures in Iran's math book (page 56)

On the contrary, in the Japanese math textbook, all the pictures are related to the lesson, so if they are removed, the learner's understanding will be damaged. Also, many concepts are explained through pictures, which is explicit in the opening pages of each chapter (Picture 17). This picture is given at the beginning of the chapter "Division", which first shows an example of division into unequal parts and then an example of division into equal parts. Then the students are asked to view the pictures and discuss with each other the differences between the divisions made.



Picture 17: Using pictures to convey concepts in a Japanese math textbook (page A24)

The eighth difference is related to the “annual program of teaching math” in Iranian and Japanese schools, which is not directly related to critical thinking, but it is mentioned because of the difference in the performance of Iran and Japan in the international test of TIMSS (IEA, 2019). Indeed, the number of required sessions for each semester is listed in the “annual program of teaching math” to help teachers plan lessons better. According to the annual plan, in Japan, 175 hours per year are considered for the Grade 3 math class. In Iran, an academic year in primary school includes 32 weeks, and in Grade 3, four hours per week are considered for math education. Therefore, in an academic year, students in Grade 3 have to spend 128 hours in math classes. As a result, the number of teaching hours of math lessons in Iran is about three-quarters of that in Japan. Also, in the Japanese annual teaching program, there are several points to consider: First, at the end of some chapters, there is a section entitled "Extension” that teaches topics that are beyond the level of other contents of the book. The teacher decides how to teach these parts based on the class level and ability of the students and the time available. Another point is to pay attention to technical vocabulary. In the Japanese math textbook, each chapter's technical vocabulary - which students are expected to have mastered at the end of the chapter - is given. During the teaching of each subject, the teacher teaches technical words and emphasizes the use of these words by students in various ways. In addition, to ensure that the teacher pays enough attention to all the technical words, the words related to that subject are mentioned in the lesson plans and textbooks at the

beginning of each subject. This feature does not exist in Iranian textbooks and "Teacher's Guide" books. It seems that the authors of school textbooks in Iran's educational system have assumed that teachers automatically teach students the meanings of words; while many of them - due to reasons such as not knowing the level of students' understanding or lack of time-, do not teach these words or do not insist on the students' use of technical words.

4. Conclusion

This research was conducted with the aim of investigating the teaching of critical thinking in Iranian and Japanese mathematics textbooks. Examining critical thinking based on eight components: Clarification, Assumption, Reason, Perspective, Alternative, Question, Prediction, and Summary. The findings reveal that the similarity between the two Iranian and Japanese math textbooks was in educational topics, the way some topics were taught, and the amount of attention paid to critical thinking components. In Japanese and Iranian math textbooks, 29.9 and 24.3% of the total questions were related to critical thinking components, respectively. This similarity was seen in the amount of attention paid to the four components of Clarification, Reasons, Question, and Summary. Farajzadeh (2013) showed that the amount of attention paid to the components of critical thinking in the third-grade math textbook is more than in other grades.

Also, the differences between the mathematics textbook of Iran and Japan were in the following cases: educational topics; the amount of attention paid to the components of Assumption, Alternative, and Prediction; use of images and characters; and the annual teaching program. Another difference between these two books was shown in terms of using different methods, practical and real problems, summarizing at the end of the educational topic, and estimating before measuring.

Regarding the teaching methods, the Japanese math textbook provided different steps to teach a topic; encourages students to check their solutions, the book, and their classmates' answers. These are related to components of Perspective and Alternative. In the Iranian math textbook, these steps for examining different views and ways were not seen. In line with this finding, Azadi & Shirvani Shiri (2018) showed that math textbooks in Japan make students think more in comparison to the Iranian math version. Izadi et al. (2014) also compared the subject of addition and subtraction in third-grade mathematics book from Japan and Iran and found that Japanese book emphasizes more on the discovery of methods by the students themselves.

In the Japanese math textbook, each chapter begins with a practical-real problem or game that arouses students' interest in learning, while in the Iranian book, the types of problems are not

related to the daily life of students. Yaftian & Firouzshahi (2020) and Mortazavizadeh & Khaleghi-Nejad (2020) also showed that questions related to the real world of children are neglected in Iran's primary school math textbooks. Considering that the applicability of a problem can lead to motivation to examine it, it seems that practical problems can be related to all components of critical thinking. Also, in the Japanese math textbook, pupils are taught how to write notes on what they have learned and use it for further learning. After teaching each topic, students are asked to discuss it with their classmates. Students measure their learning by answering final questions. The conclusion at the end of each educational topic is related to the Question and Summary of critical thinking components. In addition, although the number of questions related to Assumption is more in the Iranian textbook than in Japan, the way to deal with this issue in the Japanese textbook is important because it asks students to guess the length, mass, and time before measuring. "Estimating before measuring" is related to the Assumption component of critical thinking.

Another difference is related to the images in the books of Iran and Japan. In the Japanese book, fixed characters are introduced at the beginning of the textbook, which is present in math textbooks of different levels, and these characters are used to provide various solutions. In the Iranian math textbook, different images are used in different sections, but no significant relationship is observed between the pictures and the presented content. Since the use of relevant images and characters can lead to motivation to investigate different ways of solving problems, it seems that imagery is related to the components of Clarification, Reason, Perspective, and Alternative of critical thinking. In line with this finding, Yaftian & Abbasi (2019) indicated that the presence of nine characters in Japanese Grade 1-4 math textbooks encourages students to think and provide different solutions for word problems. According to the findings of the research, the following suggestions are recommended to the curriculum planners of primary education in Iran:

- Math textbook activities and questions should be designed in such a way that students think of different solutions to solve problems.
- In designing the problems, use the issues that the students face in their daily life.
- Authors of Iranian textbooks can take ideas from Japanese math textbooks and teach students how to take notes on what they have learned in class to summarize topics.
- It is suggested to design fixed characters for primary school math textbooks by taking ideas from the Japanese version so that these characters can be used for better teaching of math topics.

- Considering that Iranian and Japanese math textbooks have obvious differences in terms of how to solve problems; it is suggested to examine the Japanese math textbook from the perspective of problem-solving skills in future research.

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