The relationship between text and illustrations in a translated science book for children from 19th century Japan

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ABSTRACT
This article investigates the role of illustrations in a translated Western science book in late 1860s and 1870s Japan, a time when Japan was modernizing by assimilating Western concepts. In this article, we will observe the relationship between text and illustrations both in source texts (ST) and in target texts (TT). Illustrations in the TT titled *Kinmō Kyūri Zukai* are compared with drawings in the ST and TT itself. We subdivided the scientific illustrations into three categories, and the last category, which used intersemiotic translation from the TT, was strongly influenced by Japanese social codes. The drawings include appropriate people in particular situations which are suggested by the TT. We consider that this feature might have been intended to enlighten readers, especially children who encountered Western science for the first time, which means that the translator and the engraver used intersemiotic translation to show Western science.

KEY WORDS: dissemination of Western science, intersemiotic translation, science illustrations, social code, visualized knowledge

1. Introduction

Translating science from one society to another has a long history. Montgomery demonstrates that translation played an important role for new readers including scholars outside Europe by providing them with opportunities to grasp Western science through specific cases (Montgomery 2000). Other researchers have also researched translation and assimilation of Western science throughout the world or in some particular regions (Bassara 1967; Wright 2000; Chakrabarti 2004). In the case of Japan, the actual translation procedure through which Western science was converted from Western languages into Japanese has not often been studied (Morioka 1982; Sugimoto 1983; Yoshida 2000: 50-65). As a result of the translation and assimilation of Western science and technology, mostly in the nineteenth and the twentieth centuries, Japan created a base from which to build what is currently recognized as one of the most advanced countries for science and technology in the world. Researching the history of Japan's absorption of Western science offers an opportunity to shed further light on

the process of scientific translation. Hence, it is significant for us to look at the way Japanese scholars translated and publicized Western science to Japanese society within the field of translation studies, and the history of science in Japan.

This paper aims to articulate the trail of dissemination of Western scientific concepts and contents to the Japanese general public who had not encountered it during the modernization period spurred by intellectuals. The material discussed in this article is *Kinmō Kyūri Zukai*, translated and compiled by Fukuzawa Yukichi (1835-1901), which is recognized as the first popularized scientific volume for Japanese society in the history of science in Japan (Itakura and Nakura 1993: 116-119). It is of interest for researchers in both translation studies and the history of science to analyze how Western science, which included new ideas, was translated into Japanese and disseminated to the Japanese general public. Additionally, it is interesting to see how illustrations related to science were rendered or created in Japanese translated volumes as people of different cultural backgrounds have different perspectives on natural phenomena. The main question of this article is what kind of effect illustrations that elucidated Western science yielded to Japanese readers of translated science books via intersemiotic translation.

There have, however, been few such studies that have focused on scientific examples (Kemp 1990; Fu 2013). Hence, this article is a first step towards illuminating scientific illustrations from the perspective of the history of Japanese science and translation studies. Through analyses of the relationship between translated texts and drawings, we discuss the struggle to overcome cultural differences for Fukuzawa's target readers. This paper addresses both scientific translation and the history of science in Japan.

2. Historical background, Material and Translator

2.1 Assimilation of Western science in Japan

During the eighteenth century the Japanese government began facilitating the translation of Western science, medicine and technology because it found Western science (known as 'Dutch Studies' in Japan) useful to understand and apply in the military field[1,2]. The first noteworthy achievement of interpreting Western medicine on anatomy was accomplished in

[1] The *Tokugawa* Shogunate (samurai) government supported it in the *Edo* period.
[2] As the Japanese government traded with the Netherlands, books about natural science were written in Dutch. Learning Western science was called *Rangaku* (Dutch Studies) in Japanese.

1774 with the book titled *Kaitai Shinsho* (Yoshida 2000: 50-65)[3]. After its completion and up to the end of the period, the selected disciplines for translation of Western science expanded to include physics, astronomy, chemistry, medicine and others. But there was a fundamental problem: although many Dutch books were translated, there was a translation custom which had scholars writing them in full or semi-Chinese writing styles, which was only intelligible to scholars who had studied Chinese texts. In other words, such volumes were not accessible for the general public to read and comprehend the contents because most had learned only basic reading and writing in Japanese at a local private school where there were no scientific subjects at all[4].

But the situation dramatically changed after the 1850s because Japan faced the strong military power held by Western countries such as the United States, Britain, France and Russia. When the *Meiji Restoration* occurred, the new government declared a new slogan to industrialize and build up the country with strong military power, with the primary aim to catch up with advanced Western countries[5]. The intellectuals who comprehended Western knowledge, civilization and society also played an important role to show the general public Western culture. This period is called *Bunmei Kaika*, meaning cultural enlightenment and modernization, or basically 'Westernization' (Gooday and Law 1998; O'Brien 2008). Through the enlightenment period, many translated volumes related to Western science were aimed at the general public including adolescents and children. When the national educational system began in 1872, Western science became a compulsory subject for the primary school curriculum. It meant that the new government encouraged students to learn the new discipline, which can be regarded as one aspect of the governmental policy to modernize the country.

[3] The title of the Dutch source text is *Ontleedkundige Tafelen* translated and compiled by *Rangaku* doctors Sugita Gempaku and Maeno Ryotaku. Japanese intellectuals found that the drawings in the Dutch medical book were perfectly in accordance with the anatomized corpse, which reveals that human anatomy in ancient Chinese medicine, which almost all scholars studied at first, was not exactly the same as the actual body of human beings.

[4] Full Chinese means original Chinese itself, and semi-Chinese writing style means to add some grammatical characters and *katakana* (one of Japan's phonetic alphabets). Japanese local schools mainly taught how to read and write *hiragana* (the other Japanese phonetic alphabet) in primary education (Ishikawa and Tanaka, 1999).

[5] In 1867, the *Tokugawa* Shogunate government returned their regime to the emperor and the following year, the *Meiji Restoration,* known as political change, occurred.

2.2 Material and Translator

In this article, we focus on a scientific volume titled *Kinmō Kyūri Zukai*[6] by Fukuzawa Yukichi, first published in 1868. Fukuzawa has been well recognized as one of the pioneers of *Bunmei Kaika* at the beginning of the *Meiji* period. He was a multi-skilled person, namely a translator, writer, social scholar and educator. He also established *Keio Gijuku* private school in 1868, which has become one of the most long-established universities in Japan. In the early stages of his publishing career, there were some remarkable 'hits' among his books[7].
The whole meaning of the title of the book is summarized as 'to enlighten children about natural philosophy via illustrations.' As this treatise became one of the best-selling popular science books at that time,[8,9] some researchers in the field of the history of science have investigated it (Yajima 1964, Toyoda 1968, Umebara 1980). However, there is no significant previous research focusing on his translation procedures for comparison of the ST (Source Text) and the TT (Target Text) in translation studies. The reason we chose this title for our research is that this book was the first volume that allowed the general public, including children in Japan, to encounter Western science via illustrations of daily life. Yajima describes Fukuzawa and this title in the following way:

> He was not a man of science, but he recognized that the first lessons in natural science were the foundations of civilization, and he himself commenced with the popularization of scientific knowledge. Fukuzawa's book was the first of its kind and served as a model for a numerous variety of similar works. This was the situation in the eighteen seventies in Japan, the period of popularization of scientific knowledge (1964: 350).

Kinmō Kyūri Zukai is a compilation of mainly seven English source texts about Natural Philosophy and Geography, published in the United States and Britain in the 1860s (Table 1).

[6] It is written in Japanese as 訓蒙窮理図解.
[7] The first to become popular was *Seiyō Jijō*, 'Matters of the West', whose aim was to demonstrate the system and history of Western society. The second key volume for Japanese society was titled *Gakumon no Susume* meaning 'encouragement to learn' which stimulated readers to learn some Western practical skills related to their daily lives.
[8] The second and third editions were issued in 1871 and 1873, respectively.
[9] Itakura describes the sales of this title in modern science education in Japan as follows: "It seemed to bring about enormous sales after the second edition published in 1871" (Itakura 1986: vol.6 26, translated by the authors). Toyoda estimates that at least 100,000 copies were sold at that time (Toyoda, 1968: 2).

Going to the United States in 1867, Fukuzawa purchased as many English books as possible and brought them back to Japan. He explained there were several other texts he referred to.

Table 1. The main source texts for *Kinmō Kyūri Zukai*

Title of the Source Books	Author (s)	Origin	Year
A Natural Philosophy	G. P. Quackenbos	US	1866
Natural Philosophy	W. & R. Chambers	Britain	1865
Introduction to the Sciences	W. & R. Chambers	Britain	1861
First Lessons on Natural Philosophy	M. A. Swift	US	1867
Cornell's High School Geography	S. S. Cornell	US	1866
A System of Modern Geography	S. A. Mitchell	US	1866
A Pictorial Handbook of Modern Geography	H. G. Bohn	Britain	1862

Fukuzawa clearly indicates the primary purpose for his treatise in his autobiography and the preface of his works. For the purposes of our research, we have extracted some of the key sections from his remarks in the translated version (Kiyooka 1981). In the preface of collected works, he explained the main purpose for the publication of this volume. We have divided it into three parts as follows:

> In the early days after the opening of the country[10], the foremost wish of us Western Scholars was, by all means, to pull large number of citizens into our way of thinking in international relations. We had begun acting as if we were agents for the Western civilization, and we began pointing out the fogginess of Chinese learning on the one hand, and on the other we gave our best efforts in advocating the real advantages of the Western learning. Then we came upon the idea that the best was to tell people about the laws of physical sciences and let them see the light themselves. All the young students and even older persons, once they read a book of science or heard a lecture on it and came to believe it, they became men with Western ways of thinking, and instances of their turning back to Chinese ways were practically nonexistent (Kiyooka 1981: 47-48).

[10] Since the early *Edo* period, contact with Western nations as a whole was restricted (not closed off) in Japan, which was called *Sakoku* (seclusion). Foreign nations that the *Tokugawa* Shogunate government permitted to trade were China and Netherland. The visit of Commodore Perry's *Kurofune* ('black ships' meaning naval gunboats) in 1853, intended to force open Japanese trade to America, ended the seclusion. Scholars and people in Japan recognized that Japan had opened the country to the West.

In this quotation, it is clear that Western scholars, who were well-versed in the culture, science and civilization of Western society, tried to lead Japanese citizens towards modernization by showing them the physical sciences at the beginning of the *Meiji* period. One of their aims in proposing new ideas was to get rid of ways of thinking based on old Chinese theories and to show that the Western way of thinking was more practical. He continues as follows:

> I had definitely decided that the best way to lead our whole society would be to begin first with physical sciences. However, it was unthinkable to make the milliard people read foreign language books. The only resort would be a translated book. There already existed some translations published before the opening of the country[10], but those had been meant for the high class scholar's use. The language in those books was beautiful, but contained good deal of high-sounding and difficult words. Also, most of those books had been written with the chief care in translating each original word accurately with the result of becoming unintelligible to the laymen (Kiyooka 1981: 47-48).

Here, he refers to the translation culture of Japan, briefly indicated in 2-1. It was true that as translated scientific volumes were basically written for intellectuals, with Chinese writing style, most readers did not know what was meant. Next, he explains his translation strategy, which emphasizes not precise translation, as before, but intelligibility for the general public. Lastly, he summarizes it in the following way:

> I picked from several different books those sections which I deemed necessary for elementary instruction, and without regard at all to the original wording or material, I simply took the substance and as if I was writing an original textbook for the Japanese people, produced a book which became *'Kyuri Zukai'*... (Kiyooka 1981: 48-49).

The contents he chose for the primary direction of Western science are shown in Table 2. For example, he did not choose 'matters and motion' or astronomy which are the initial subjects in the source books he referenced. Instead, he began with heat, which was found in the later chapters of the source texts.

Table 2. Chapters Fukuzawa treated in *Kinmō Kyūri Zukai*

Volume 1		Volume 2		Volume 3	
Chapter	Title	Chapter	Title	Chapter	Title
1	Heat	3	Air	7	Attraction (Gravitation)
2	Water	4	Wind	8	Day & Night
		5	Cloud & Rain	9	Seasons
		6	Hail, Snow, Dew, Frost, & Ice	10	Eclipses

We also need to confirm Fukuzawa's target readers for this title because it is crucial to understand this before we can embark on a discussion of the illustrations. He clearly specifies his target readers as follows:

> And here I came to the conclusion that I must change the whole style, of expression in order to reach a wider public…And so, I mixed the popular Japanese and the graceful Chinese together in one sentence … all for the convenience of reaching wide circle with the new thoughts of the modern civilization.
> At that time, I used to tell my friends that I would not be satisfied unless these books could be understood by uneducated farmers and merchants, or even a serving woman just out of the countryside when read to her through the paper door … I let women folks and children in my house read it for rewriting those portions which they had difficulty in understanding (Kiyooka 1981: 6).

We can thus see Fukuzawa's passion to introduce Western science to a wide range of the general public. Judging from the description of his objectives, he wished this volume to be intelligible, in other words accessible, not only by reading but also by listening for those who were illiterate. He also explained in the preface of the volume, as "the reason of issuing this small volume is to help to enlighten children... Hence, we put the word *Kinmō* (to preach to children)" (Fukuzawa 1868: iii, translated by the authors). Even though he noted that the range of his target readers was wide, it is clear from the statement above that his main focus for readers was children. His desire to enlighten children might have affected not only texts but also illustrations in the volume.

3. Methodology

For reasons of space and in order to focus more on the data under analysis, we have kept the theoretical discussion to a minimum. The following references serve to contextualize the theoretical tools we have used in our analysis. Quantitative data results drawing on our analysis will be provided in the discussion section of the paper.

The way in which the textual contents and the visual contents interact with each other in illustrated books has long been recognized. For example, Kress and van Leeuwen state that picture books can be defined as multimodal texts using "more than one semiotic code" (1996: 183). In this context, Oittinnen also demonstrates that readers can understand the contents via two different semiotic codes, verbal cues and visual cues, while reading a book (2008: 84-85)[11]. But as Oittinen points out, there are few researchers who have conducted analyses of illustrations in Translation Studies (Oittinen 2000: 5).

In this article, we will analyze the relationship between texts and illustrations both in the ST and in the TT on the basis of Jakobson's statement about 'intersemiotic translation'. He states that "intersemiotic translation or *transmutation* is an interpretation of verbal signs by means of signs of nonverbal sign systems" (Jakobson 1959/ 2012: 127). Comparing ST with TT, if there are no illustrations in the ST, and an illustration emerges in the TT, it is apparent that verbal information is transferred into non-verbal information in the TT via intersemiotic translation. Pereira recognizes book illustrations as intersemiotic translations from the text of the illustrated book. In her article, she explains the procedure of establishing illustrations in a picture book as follows:

> (T)he establishment of the text as the source work and the pictures as the target work in illustrated book…The text can be regarded as the primary source because it is usually the first work to be created, the pictures being derived from it. (2008: 105)

In the first comparison, we investigate the relationship between texts and illustrations with particular reference to the five main distinctions made by Nikolajeva and Scott, as shown in

[11] Especially in visualized scientific texts, Evagorou and Osborne explain, "meaning in science is constructed through a judicious use of charts, graphs, symbols, mathematics, diagrams and words" (2010: 142). They affirm that the construction of meaning in science is determined with appropriate use of other types of signs.

Table 3 (2000, 2001).

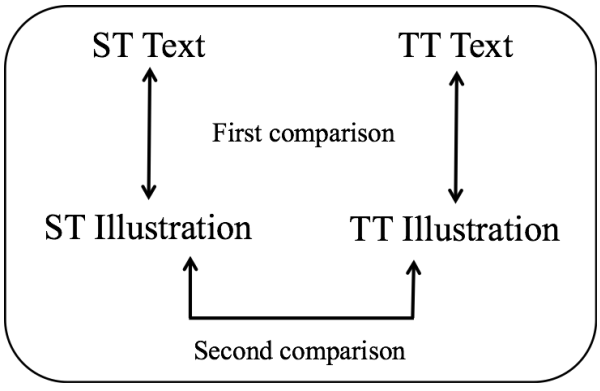
Table 3 Interactions between words and pictures by Nikolajeva and Scott (2000)

Name of Interaction	Function
Symmetrical	Words and pictures tell the same story, essentially repeating information in different forms of communication
Enhancing	Pictures amplify more fully the meaning of the words, or the words expand the picture so that different information in the two modes of communication produces a more complex dynamic
Complementary	Enhancing interaction becomes very significant (2000: 225-226) If words and images fill each other's gap wholly, there is nothing left for the reader's imagination (2001: 17)
Counterpoint	Words and images collaborate to communicate meanings beyond the scope of either one alone
Contradictory	Words and pictures seem to be in opposition to one another

In the second comparison, we analyze illustrations in the ST and those in the TT (Table 4). We use these terms as theoretical tools when we look at the drawings in *Kinmō Kyūri Zukai* in order to show the function of illustrations and the relationship between them and texts, which is necessary for further discussion of intersemiotic translation.

Analyzing illustrations, we try to focus on code from the point of view of communication. In this context, Cooley points out that code is "a culturally defined, rule-governed system of shared arbitrary symbols that is used to transmit meaning" (1983: 242). Leeds-Hurwitz explains further that "because codes are culturally based, intercultural communication research must eventually pay attention to codes and how they function" (2012: 71).

Table 4. Procedure of the analysis



As Japanese culture and Western culture were relatively different, several social codes such as bodily code (appearance) of human beings or commodity code (fashions, clothing) seem to embody the differences between these cultures (Chandler, 2007: 147-149). In other words, it is key in a study like this to analyze the way translators converted the contents to fit the target culture.

4. Analyzed data on comparison of illustrations

After counting the total number of illustrations depicted in *Kinmō Kyūri Zukai,* we can see that more than 30% of the drawings include the clear appearance of human beings (nineteen out of fifty six illustrations in three volumes). As these illustrations in the TT are placed between the texts, readers can easily find the connection between the content of the text and the illustration. With regard to the figures found in the TT, we have been able to classify them into three categories: (1) those almost the same as the ST figure; (2) those with additional description; and (3) those in which human figures not found in ST texts appear. The third type also shows Japanese social codes, which is the result of intersemiotic translation mentioned above. We will discuss the functions behind the different illustrations found in the TT compared to the ST from both the contextual and semiotic perspectives in the next section.

4.1 Category 1 (almost the same illustration as the ST)

The first example we look at is the structure of snow. We focus on the main text both in the ST and the TT and its illustration in Figure 1. As the TT is written in Japanese, we carried out a back translation (BT) for the ST text that corresponded to the illustration in the TT.

> (ST) They (snow-flakes) aggregate, according to the law of crystallisation of water, into regular and symmetrical forms, of which the general character is a six-sided figure; as, for example, six needles branching from a centre, or six arms from a six-sided nucleus, each needle being three or six sided. Though single crystals always unite at angles of 30°, 60°, or 120, they nevertheless form, by their different modes of union, several hundred distinct varieties of snow-flake, some of which are figured in the preceding engraving ([Meteorology] *Natural Philosophy*, Chambers 1860: 42).

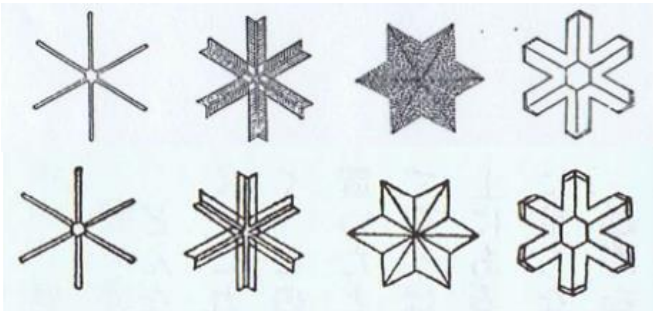
> (TT, BT) snowflakes look just white and as if they were falling blossoms or cotton.

> When you observe it with a good convex lens, the shape of snowflakes absolutely consists of a six-sided figure as the illustration above ([Hail, Snow, Dew, Frost, & Ice] *Kinmō Kyūri Zukai*, Fukuzawa 1868 (2): 21).

Figure 1. Illustrations (snow flakes) in the ST and the TT

ST

TT



Both texts explain the figure of a snowflake although there are slight differences found between the ST and the TT. Fukuzawa omitted the concept of aggregation of watery particles being a 'law,' the angle of snowflakes, and preserved the hexagonal structure of snowflakes in his translated text. One of the features about Fukuzawa's translation strategy is that he often inserted additional expressions and reduced what he judged to be redundant or difficult explanations for his target readers, with the intent to make his narrative clearer and easier for them to comprehend the content.

Looking at the illustrations in Figure 1, we have categorized the illustration in the TT as (1), almost the same illustration as the ST. Although the contents of ST and TT are different, the concept of the figure of snow remained. As we can find that both drawings in the ST and the TT show the six-sided structure of the snowflakes from each main text, the interaction of both illustrations can be determined and considered 'symmetrical' (repeating information in different forms of communication) following the categorization by Nikolajeva and Scott (Table 3). Focusing on the details of illustration, we can find that the shape of snowflakes in both engravings is almost the same. It means that the engraver in *Kinmō Kyūri Zukai* referenced the illustration in the ST[12]. However, the two flakes shown in the centre in the TT illustration look simpler than those in the ST. Looking at books about Japanese woodcuts, the fine engraving was possible for Japanese engravers to make (Strange 1904; von Seidlitz

[12] The relationship between Fukuzawa and the engraver is still unknown.

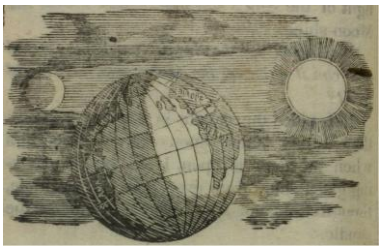
1910). Hence, this simplification can be understood as a means to publish as many duplicate volumes as possible to show Western science to many Japanese as quickly as possible. The same feature is shown in Figure 2 as well. Figure 2 (1) indicates the relationship between the earth, sun and moon. Figure 2 (2) shows balls hung by a long string to observe the attraction between the balls.

Looking at the illustrations translated from Dutch into Japanese in the previous period, almost all figures were the same, and simplifications were not carried out (Figure 3). It could be considered that these volumes were mainly translated for intellectuals, and the translator might have pursued literal translation as the ST shows. In contrast, as Fukuzawa tried to disseminate the concept of Western science to the general public including children, he emphasized not the literal description of the contents but rather the key concepts of science. Indeed, looking at Figure 2 (1), the lines showing longitude and latitude are omitted. Actually, Fukuzawa did not translate the concept of them in his description and only mentioned that the earth was round. This is because it was common for local Japanese to conceptualize the earth as flat at that time[13].

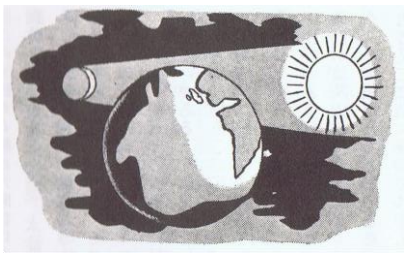
Figure 2. Illustrations in the TT almost the same as the ST

(1) Relationship among three heavenly bodies

ST (Swift)



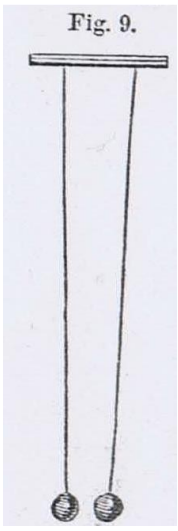
TT



[13] Katayama Junkichi (1859-1933) said that he and other members of his village in Okayama believed that the earth was flat in his youth until he learned otherwise (2000: 44).

(2) Attraction of two balls

ST (Quackenbos) TT



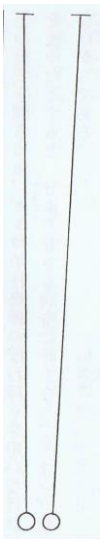
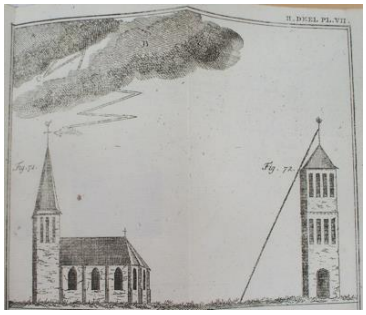
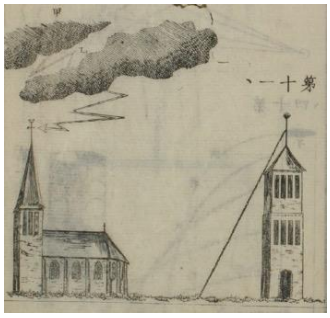


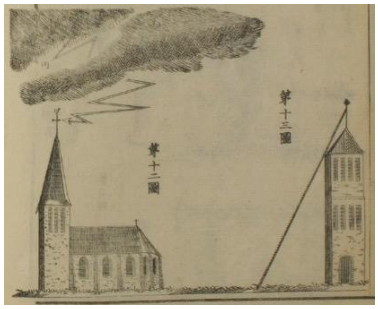
Figure 3. Comparison of illustrations translated from Dutch volumes in the *Edo* period[14]



ST
Natuurkundig Schoolboek



TT1
Kikai Kanran



TT2
Kikai Kanran Kōgi

4.2 Category 2 (additional description)

The second category demonstrates that some illustrations in the TT contain additional material. First let us compare the relationship between the main texts and illustrations about a scientific instrument in the ST and TT shown in Figure 4.

(ST) It is a glass tube with a bulb at the bottom, into which mercury or quicksilver is

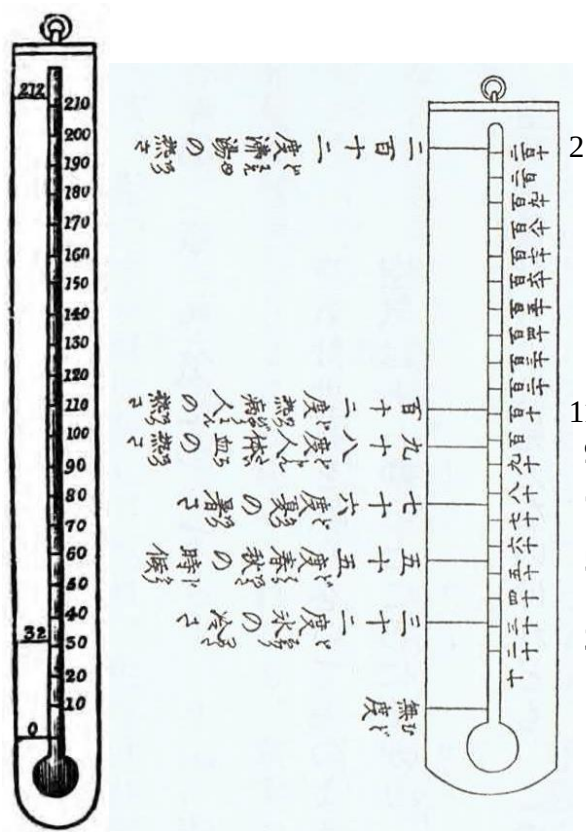
[14] The ST is *Natuurkundig Schoolboek* by Johannes Buijs（1822）, the TT1 is *Kikai Kanran* translated by Aochi Rinso (1825), and the TT 2 is *Kikai Kanran Kōgi* translated by Kawamoto Komin (1851-1856).

> put, with a scale of figures along the tube to mark the rising of the quicksilver … In the scale of figures, 32 is marked as the freezing-point; that is to say, when the mercury is at 32, water freezes; and the more it is below that point, the more intense is the frost. When it falls to 0, it is said to be at zero; at 60, the air is reckoned temperate; 98 is the heat of the blood in the average of living men; and 212 is the point at which water boils ([Heat] *Introduction to sciences*, Chambers 1861: 46 no.105).
>
> (TT, BT) The way to make it is to put the glass tube to the glass bulb, and put mercury into it. Then we can measure the temperature by its rising and falling… The illustration on the left is a thermometer with its scale divided into 212 degrees. As drawn, when it is put inside boiling water, the mercury rises and it reaches 212. When it is put in ice, the mercury sinks to 32. We can assess the temperature of the four seasons and measure hot and cold water by those scales. '0' is written as the bottom point. This temperature is 32 degrees lower than the temperature of ice. It is the temperature of extreme cold ([Heat] *Kinmō Kyūri Zukai*, Fukuzawa 1868 (1): 9).

As seen in the text comparison, both texts indicate the function of the thermometer and its scale, although we find that the description about the particular temperature is different. It is clear that Fukuzawa reduced some of the descriptions in his translation. Looking at the illustration, as the shape of the thermometer is almost the same, it means that the engraver also referenced the main figure in the ST. Although the numbers are written differently, it was natural for Japanese to use *kanji* (Chinese ideograph characters) to indicate numbers at that time. The important point is that the thermometer is drawn only with numbers in the ST illustration; in contrast, it is written with numbers and short captions in the TT illustration. Looking at them carefully, it becomes apparent that all information about particular temperatures is described in the main text in the ST. The drawing in the ST is merely showing both its shape and the scale of a thermometer, whose interaction is 'complementary' (words and images fill each other's gaps) to the main text. ST readers can connect the information depicted in the text and each degree in the figure of the thermometer in the ST for themselves.

Figure 4. Illustrations of a thermometer

ST TT



212 °F: Temperature of boiling water☐

112 °F: Temperature of fever☐

98 °F: Normal temperature of our body☐

76 °F: Hotness in summer☐

55 °F: Comfortable temperature in spring and autumn☐

32 °F: Temperature of ice☐

Zero☐

In contrast, although the description in the TT tells us, like the ST, about concrete temperatures such as 212°F, 32°F and 0°F, other temperatures described in the ST are not found in the main text of the TT. Instead, the illustration in the TT contains short captions for each crucial temperature of the thermometer, which tells us the temperature related to everyday experiences in our lives such as 55°F and 76°F for seasonal temperatures and 98°F and 112°F for body temperatures. This change can be categorized as the main text being shortened and inserted into the TT illustration as a caption. Here, the interaction of the drawing in the TT appears to be both 'symmetrical' for 212°F, 32°F and 0°F, and 'enhancing' (pictures amplify more fully the meaning of the words) for other temperatures underlined in the TT main text. Here, to amplify means that the captions in the illustration tell the details of average air temperature of each season compared to just saying 'four seasons' in the TT. Additionally, Fukuzawa added a caption about our average body temperature and temperature during a fever, which was not described in the text.

This kind of drawing with additional description, which is rarely seen in the ST, is found not

only for the explanation of scientific instruments but also for the illustration of scientific principles in many chapters of the TT. Figure 5 shows other examples with either 'symmetrical' or 'enhancing' interactions.

Figure 5. The illustration comparison in the ST and the TT

(1) The nature of convex lens to accumulate heat

ST

(Quackenbos)

TT

(enhancing)

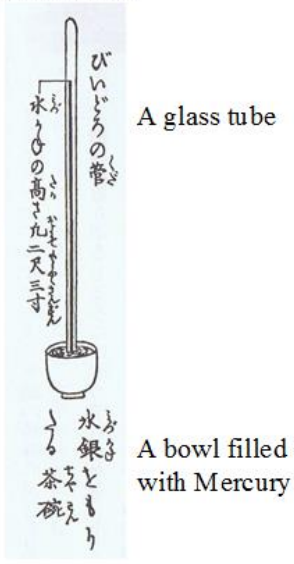
(2) The figure of barometers

ST

(Quackenbos)

TT

(symmetrical)



4.3 Category 3 (the appearance of human beings)

The last category of illustrations includes the appearance of human beings. In general, when human beings are sketched in the scientific texts, most of them are conducting an experiment with some scientific instrument. In Dutch textbooks of natural philosophy, which most *Rangaku* scholars and students learned until the 1860s, there were almost no illustrations of human beings. As we saw in Table 1, Fukuzawa referenced British and American volumes as the ST; there are some drawings concerned with human beings conducting experiments or doing something. Here, we show some examples of illustrations found in the TT compared with the texts in the ST and the TT. The first examples shown in Figure 6 are two illustrations of a woman. The number before the ST begins corresponds to the illustration.

(1) (ST) When boiling water is poured into china cups and glass vessels, they often crack ([Heat] *A Natural Philosophy*, Quackenbos 1866: 523 no.208). [No illustrations]

(TT, BT) When we put hot liquid into a cold china bowl, they sometimes crack ([Heat] *Kinmō Kyūri Zukai*, Fukuzawa 1868 (1): 7). [An illustration appears]

(2) (ST) A polished metal surface, such as silver or tin, both radiates heat more slowly, and also absorbs it more slowly（Chambers, 1861: 45 no.103）. [No illustrations]

(TT, BT) A polished metal absorbs heat slowly and radiates slowly... Maidservants, although you may work harder, you do not have to polish the bottom of the pot as if it is platinum. It becomes waste of firewood ([Heat] *Kinmō Kyūri Zukai* Fukuzawa, 1868 (1): 8). [An illustration appears]

Figure 6. Illustrations of Japanese women

(1)

(2)

For Figure 6 (1), there are no illustrations in the ST to describe the expansion of a china cup due to heat. But we note that there is one drawing in the TT, which looks to be the result of intersemiotic translation. Looking at Figure 6 (1), it clearly shows us the exact situation, which the text explains to be when the china cup held by the woman cracks after boiling water is poured into it. Here, the woman who is not indicated in the text appears in the illustration, which means that the figure functions as a 'counterpoint' (words and images collaborate to communicate meanings beyond the scope of either one alone) with the main text. The collaboration between words and images suggests to readers that the incident occurs in their everyday lives.

Looking at the woman in Figure 6 (1), we can see that she is Japanese because her face is not like depictions of Western people at the time and her hair is put up in the traditional hairstyle for Japanese women. Additionally, she wears a striped Japanese *kimono* with a white apron in front of her and Japanese wooden clogs called *geta*. When this volume was published, the kitchen was placed either far from or next to the dining room in a traditional Japanese house. Residents take off their shoes and climb one step up to the rooms in the house. As the height of the kitchen was the same as the ground level and connected to the outside by a door, there was a small step down from the dining room or corridor when someone needed to go to the kitchen. Therefore, those who worked in the kitchen must have worn *geta* at that time. Although the background was not completely illustrated in Figure 6 (1), it was natural for readers to imagine that the situation drawn here was in the kitchen. Here, the procedure of drawing is firstly interlingual translation from the ST (English) into the TT (Japanese) and secondly intersemiotic translation from the translated TT (Japanese) into the figure. It seems unimaginable to translate directly from the ST (English) into an illustration. Judging from the woman, she is depicted according to the Japanese bodily code (face, hairstyle, etc.) and commodity code (*kimono*, *geta*), which would be familiar and common for most of Fukuzawa's target readers. We can thus estimate that the figure was drawn from a Japanese text. These two steps of translation have been carried out in sixteen other illustrations apart from the two mentioned above[15].

Looking at Figure 6 (2), this was also the result of intersemiotic translation and was affected

[15] Approximately 95 % of human beings are drawn via two steps of translation procedure (Eighteen out of nineteen).

by the two kinds of code. Fukuzawa has added the sentence and illustration. The text here is not aimed at explaining a phenomenon but rather a message about female maidservants. In Figure 6 (2), a woman in the same code as Figure 6 (1) has a pot for cooking rice in her left hand, and a rasp or stick to get rid of burnt material in her right hand because this figure is intended to express the relationship between the roughness of the surface and heat absorption. The interaction of this illustration is 'symmetrical' in that words and pictures tell the same story as the main text. Judging from the relationship between the text and the figure, she must be a female maidservant. Since women rarely appeared in such scientific books in that period in Japan, this aspect is worth discussing. Another example is shown in Figure 7, where the two gardeners on the right and left wear clothing in accordance with Japanese gardener style. The gardener on the left is wearing a Japanese *geta* for outdoors and is equipped with scissors held by his belt under the Japanese commodity code.

Figure 7. Illustrations of Japanese gardeners

The three examples of illustrations analyzed in this section suggest that Fukuzawa tried to 'iconize' the scientific phenomena or related activities from verbal signs into visual signs with reference to particular social codes (Oittinen 2000: 5). As we have seen, the illustrations can be divided into three main categories. Summarizing the results from categorization and analysis, we discuss why Fukuzawa selected such kinds of illustration in *Kinmō Kyūri Zukai,* and the importance and effects of illustration in the next section.

5. Results and Discussion

In this section we will discuss the illustration analysis in section 4 along with other factors such as Fukuzawa's purpose for publication and the cultural background of readers. As Fukuzawa tried to show Western scientific principles to a wide range of the general public, it seemed to be important for him to show not detailed science but general scientific concepts. The dominant way of thinking of the public was historically constructed by ancient Chinese virtues according to which everything occurred due to two kinds of minds known as *yin* and *yang* as stated by Zhu Xi in the twelfth century (Patterson 2000; Wang 2005). It asserts that any natural phenomena, such as dew or lightning, are caused by different patterns of interaction between *yin* and *yang*[16].

Fukuzawa's statement in 2-2 indicates that he tried to challenge the old Chinese way of thinking which he described as 'fogginess'. Simultaneously, he attempted to introduce Western ways of thinking based on science that were practical and expressive of reasons or rationality[17]. The relationship between the first category of illustration analyzed in 4-1 and the basic ways of thinking of most readers at that time can be explained against this background. The results of the simplification in Figure 1 and Figure 2 seem to be effective in showing general concepts and phenomena related to the natural world to introduce readers to what the material world consists of. Illustrations are also a good way for Fukuzawa to simplify these concepts and phenomena for first-time readers to indicate specific information such as the hexagonal shape of snowflakes in Figure 1, and the shape of the earth in Figure 2 (1). Therefore, the interaction of these figures is mainly 'symmetrical', a way to repeat information of the TT as simply as possible. We confirmed that the amount of this type of illustration is about 10 % (four out of thirty seven[18]).

The second type of illustrations with additional description in Figure 4 and Figure 5 interacts with texts in a 'symmetrical' or 'enhancing' manner. The illustrations were about measurements, scientific instruments and principles. As the measurements were rare when

[16] There are two main concepts called *yin* and *yang* and five sub-concepts of wood, fire, soil, gold, and water (Fukuda, 2009). Goto Makita (1853-1930) mentioned that when he read an encyclopedia titled *Setsuyō-shū*, there was a description about dew and lightning, which was explained by *yin* and *yang*.

[17] With regard to the education in the Eastern world such as Japan and China, Fukuzawa points out a lack of studies in number and reason in material culture (Kiyooka 1981: 215).

[18] As we pointed out that nineteen illustrations out of fifty six are related to human beings, the remaining thirty seven are not relevant.

this volume was published, most of Fukuzawa's target readers did not know about the shape, mechanics of such instruments, and the principles behind them. Hence, it would have been impossible for readers to comprehend the function that illustrations with long descriptions in the main text fulfil, or their interaction with illustrations without captions. This shows that the interaction between texts and illustrations changed from 'complementary' in the ST to 'symmetrical' or 'enhancing' in the TT. Figure 5 (1) indicates in chronological order how the heat from the sun focuses at one point via a convex lens. If the caption is removed, readers cannot understand what the figure is about. Consequently, the additional description was necessary for Fukuzawa to introduce unconventional instruments and explanation of principles for his target readers. We confirmed that the amount of this type of illustration is around 30 % (eleven out of thirty seven).

For Figures 6 and 7, it is worthwhile to discuss why Japanese women with traditional hairstyle in traditional clothes such as *kimono* and gardeners with traditional clothes appeared in the TT. For Figure 6, although there are no descriptions of women in the ST or the TT, the choice for the drawing of a Japanese woman, who rarely appeared in previous scientific publications, became possible due to intersemiotic translation from the TT to the illustration. Both of the illustrations of Japanese women under the Japanese bodily and commodity code shown in Figure 6 were found in chapter 1 [Heat]. In this chapter, Fukuzawa was explaining the nature and features of heat through various cases. For instance, he talked about the expansion of materials due to heat and showed many examples such as an iron rod for the expansion of a material in a solid state, alcohol for the liquid state, a Japanese bathtub and so on. Such examples are not Western but Japanese, which means that Fukuzawa substituted Western objects with Japanese ones[19]. In other words, he localized materials in order to make it easier for his target readers to grasp the contents in the Japanese cultural context. Among these examples, Japanese women appear when he talked about a china cup and pot. China cups were often used at the table when people drank soup, tea and alcohol, and the pot was used to cook rice in Japanese homes at that time. To express the cracked china cups, it was possible for Fukuzawa to show just the illustration of the broken object itself. But the Japanese women with Japanese hairstyle in accordance with Japanese bodily code at that time

[19] Fukuzawa declares that he substituted Western objects with Japanese objects in the explanatory note before the main text begins.

appear with particular objects in the illustration. As women who worked in the kitchen mainly handled those cooking items, the description of a china cup and pot with the illustration of women holding them was an ordinary scene for readers. The illustration shows that the description of phenomena related to the objects, explained by Western science, also appear in the readers' lives. In addition to that, we can confirm that the Japanese commodity code also appears because the illustrated women wear Japanese *kimono*, normal costume for Japanese women at that time. The design of the *kimono* is simple, without gorgeous ornamental depictions, suggesting that the women in the illustration belong not to the upper social class but the same social class as the readers. When they read the texts and look at the illustrations they can easily connect that the incident actually happens in their daily lives due to the interactions of 'counterpoint,' in which words and images collaborate to communicate meanings beyond the scope of either one alone. The woman in Figure 6 (2) must be a servant according to the main text. It may sound surprising that a female maidservant appears in a Japanese scientific text. However, it is Fukuzawa's steadfast strategy in his treatise to show that indigenous Japanese were related to natural science.

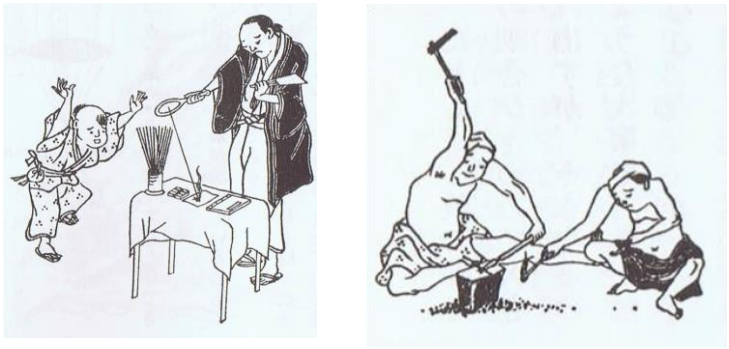
Other human beings appeared in the illustrations in the TT such as gardeners in Figure 7, children, a blacksmith, and local people in Figure 8. The fact that these illustrations were not found in the original ST raises the question of why they appeared under the Japanese social code (bodily code by face and hairstyle and commodity code by clothing) in this volume. Looking at previous translated treatises before *Kinmō Kyūri Zukai*, such as *Kikai Kanran Kōgi*[14], most books related to science had illustrations of experimental apparatus or human beings who conducted experiments with particular instruments. This tendency continues partially in this volume when Western people are drawn using particular scientific instruments such as a microscope, a telescope and a terrestrial globe in Figure 9. But indigenous Japanese appeared in the illustrations with their daily tools and activities in this volume. One reason might be that using many types of citizens who were close to the readers, in the same way as the appearance of women discussed above, might have made it easier for them to accept Western science through familiarity with the images, even though they would be new concepts for them. In other words, it makes readers realize that natural phenomena are explainable by reasons supported by Western science, which is different from previous ways of thinking. What is more, it is important to notice that children are depicted in this text.

Children are drawn in three figures out of nineteen, which helps young readers feel that the contents are related to themselves. The appearance of such people within the text is similar to the picture books in the previous era in Figure 10, whose contents were not scientific. These similarities in the illustrations suggest that readers might have felt as if they were not reading a scientific text but a novel because of the many illustrations of indigenous Japanese who were compatible with the scientific contents of the written text. Approximately 84 % of human beings are drawn as indigenous Japanese (sixteen out of nineteen).

As Fukuzawa wished to reach a wide range of the general public, especially children, to help them to comprehend Western science, he used examples related to daily phenomena that were taken from his interlingual translation. In addition, many indigenous people under the Japanese social code in contexts relevant to the phenomena appeared in the illustrations which could be appreciated due to the knowledge and experiences of readers. Inserting illustrations of local people suited to the social code may have made the contents more intelligible and comprehensible[20]. The reason he utilized such techniques for illustrations with engravers was to create the initial and crucial step in order to modernize Japan by changing people's way of thinking through reading Western science. From the readers' perspectives, the appearance of indigenous Japanese with daily phenomena in the illustrations may have increased the accessibility of Western science for them. It helped readers to read, accept and comprehend the contents sufficiently by reading the main text along with familiar illustrations.

Consequently, after Fukuzawa's publication, indigenous Japanese began to appear in the illustrations in some of other translated texts of Western science. Drawings in Figure 11 show that Fukuzawa's efforts influenced other works.

Figure 8. Local Japanese people including children drawn in illustrations



[20] Oittinen emphasizes the idea that illustrations play an important role, especially for children who are illiterate. Continuously, she indicates that illustrations may often be more important than the words (2000: 5). As illustrations can be identified as an icon indicating something in our world, they may help illiterate children with comprehending the meaning in the text.

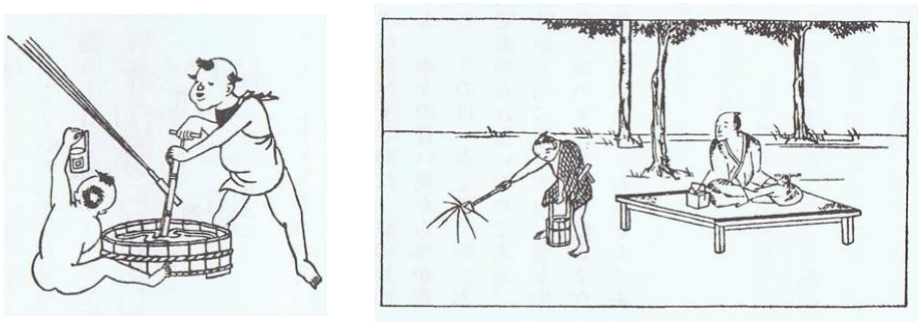


Figure 9. Western people drawn in illustrations

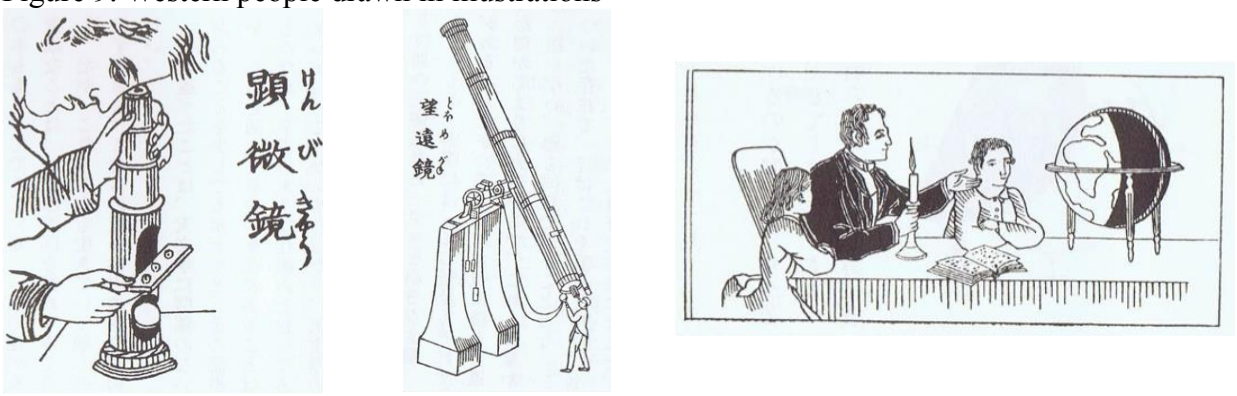


Figure 10. Local people drawn in illustrations in ordinary picture books[21]

[21] From *Tokaidō Chū Hiza Kurige* published from 1810 until 1822, written by Jippensha Ikku.

Figure 11. Illustrations in the scientific volumes after *Kinmō Kyūri Zukai*[22]

(1)

(2)

(3)

6. Conclusions

We conducted a comparison between the texts and illustrations in a book about Western science translated from English into Japanese, titled *Kinmō Kyūri Zukai,* and those in its English ST[23]. On the basis of the comparison, we classified the TT illustrations into three categories which are (1) almost the same as the ST, (2) with additional description, and (3) with the appearance of human beings in the TT, not found in the ST.

The illustrations in (1) are simplified compared to those used in the ST, which indicates that the contents that the drawings show were selected in order to help readers grasp one important point to reveal details about the material world and natural phenomena different from facts known by readers in the past. In (2) short descriptions were added in order to help readers understand what the figure means when they look at it for the first time. Illustration (3) includes appearances of local people including women, gardeners, craftsman and children with Japanese bodily and commodity codes, which is the result of two steps of translation: an initial interlingual translation from the ST into the TT and intersemiotic translation from the TT into the figures.

[22] (1) *Dōri Zukai* translated by Tanaka Daisuke, published in 1869, (2) *Kyūri Wage* written by Nakagami Tamotsu, published in 1872, (3) *Kyūri Benkai* translated by Mochizuki Makoto, published in 1869.

[23] With regard to Dutch science, Montgomery states that it had become the language of Western science by the first decade of the nineteenth century. He continues that it remained so until the beginnings of the *Meiji* era. The *Meiji* government extended learning foreign science in each field in different languages, such as English and American naval power, French chemistry and astronomy, German physics and medicine (Montgomery 2000: 215-217). This means Dutch science became less important than before.

From these results, we can observe a trend Fukuzawa initiated, which changed the way of drawing illustrations compared to previous volumes, which were almost the same in detail as the ST. Simplification and additional description aided local readers, as they encountered Western science for the first time, to understand its contents and concepts more clearly. Fukuzawa's system relates the appearance of human beings with Japanese bodily and commodity code which helped his readers realize that the natural phenomena they experienced are explained by Western rational ways of thinking underpinned by scientific reasons. This meant that science became intelligible and accessible within readers' lives under daily circumstances in Japanese contexts.

One reason for such modification of illustrations is related to Fukuzawa's primary purpose: to illustrate Western science so that a wide range of readers, especially children, could understand its principles and how it challenged their traditional way of thinking. In particular, it is noted that all drawings are based on the physical world and are devoid of mythological contents. By this means, Fukuzawa led readers to realize that any natural phenomena occur not through mystical reasons, but as a result of verifiable reasons based on a small number of scientific concepts and principles. Fukuzawa guides readers to focus on the material world when something occurs.

Fukuzawa tried to introduce Western science to the general public not only via texts but also via illustrations. Other authors and translators published scientific treatises with familiar illustrations, in the same manner as Fukuzawa did, for indigenous readers after Fukuzawa's publication. It indicates that Fukuzawa's effort affected other volumes, which means that other authors and translators accepted Fukuzawa's strategy to communicate Western science to the general public. Looking at illustrations is one of the practical strategies to discuss how verbal contents are converted to visual contents. Indeed, we can consider why such conversion was carried out in the volumes analyzed. This study has shown that are opportunities for further research to determine the relationship between illustrations and the understanding of science more precisely, and to clarify the exact effects of illustrations of translated scientific texts on readers.

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