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A Composition of Content Based on Count Principle Method for Reeducation of Mathematics Teacher

Karasawa Toshimitsu
(University of Manchester, UK)

Abstract: This paper examines the enumeration principle of Rikitaro Fujisawa and that of Knilling, and defines the principle as a method that covers the contents of the first government-designated textbook in Japan. In this paper, I also introduce my study that has been organized from the viewpoint of the enumeration principle, which has been regarded as one of the mathematics educational indexes of the current arithmetic textbook for elementary school in Japan.

Key words: Arithmetic Textbook, Count Principle Method, reeducation of teacher

1. Introduction

Today, some people think that the arithmetic textbook used in elementary school in Japan has not been strongly influenced by the first government-designated textbook because it is rather somewhat influenced by the Green Cover Textbook and modernization. It is thought that it would be important to define the inevitability and eventuality of the present arithmetic textbook in Japan, to examine the specific effectiveness of causes, and to consider the possibility of the/an arithmetic textbook in the future. This paper organizes enumeration principles as one of the indexes for us to examine present number education using an arithmetic textbook in Japan and introduces the enumeration principle described in the first government-designated textbook. Specifically, I will organize all the methods that make up the contents of the textbook in Japan at that time.

As for the first government-designated textbook in Japan, most people usually point out that its contents were influenced by Rikitaro Fujisawa and were based on his enumeration principle. It is thus necessary to define what kind of enumeration principle this is in the first place. It is generally said that Rikitaro Fujisawa had an influence on mathematics education for junior-high school through “Mathematics Rules and Teaching Methods” in 1985 and “Teaching Method of Mathematics” in 1900, etc. Educators often point out that the enumeration principle of Fujisawa who was also a mathematician was a shallow and psychological principle based on mathematical theory and it targeted secondary education rather than elementary education. Since no case of actual class teaching the principle has existed till today, it is thus very difficult to detect the underlying thinking that had affected the way of preparing and compiling the first government-designated textbook for elementary school in Japan in those times.

However, it is pointed out that it seems to be targeted daily life for the primary purpose of arithmetic. For

Karasawa Toshimitsu, Ph.D., Local Assistant, University of Manchester; research areas: education, information science, history of science. E-mail: karasawat10@yahoo.co.jp.

example, the textbook describes as follows: "... to teach addition, subtraction, multiplication and division; ordinal scales and measures; currency; usual and appropriate miscellaneous problems; common and decimal fractions; proportion; and problems of interest." As for other enumeration principles, there is the one that Knilling has presented from the psychological viewpoint in German. It is well-known that an actual example of the direct influence is seen in the study of Takeshi Sato, a practical educator of arithmetic education.

2. Enumeration Principle of Rikitaro Fujisawa

Some people point out that Fujisawa's interest in mathematics education shifted from secondary education to elementary at the time when he wrote "Writing for Lecture on Educational Method of Mathematics". In addition, it is also said that he has written on teaching methods for elementary school, but has not prepared specific educational details. Others point out that he has only described the practical contents of the "Arithmetic Textbook" (a textbook for normal school and junior-high school). The characteristics are summarized in that quantity is excluded from the teaching of a number concept and that integral addition, subtraction, multiplication and division are systematized by counting in numeration and notation methods.

Accordingly, a number is taught by focusing on remembering the numeral rather than by handling a discrete quantity. As for a numeral in the Japanese language, it has the characteristics that both "Ichi" (one) and "Ju-ichi" (eleven) are of an equal existence in the numerical group because it does not include the system where the ten is counted as a unit, contrary to English expressions such as there are three tens or there are twelve tens, although numeral in Japanese originally includes the decimal structure.

Addition is defined by a shift in the numerical group. For that reason, both addition, as the elision of "counting up" operation, and subtraction, as the elision of "counting down" operation, are explained as a shift in the numerical group. As a result, a bigger number becomes a number of the subtracted side and comes to exist on the right of the numerical group. Therefore, we could see the possibility here that the mathematician Rikitaro Fujisawa might have fully recognized that point and thus did not daringly explain any concept of big and small. Multiplication is defined by a cumulative method. The multiplier is regarded as a number that does not indicate a shift in the numerical group, but the number of shifts. In addition, as for unit conversion in the decimal compound number for metric measurement and others, it adopts the order from cardinal number to ordinal number after explaining the special number. As for the calculation method of division, it is basically the same as that of multiplication, it gives two kinds of definitions of the measurement division, "(concrete number)/(concrete number) = (abstract number)", and the sharing division, "(concrete number)/(abstract number) = (concrete number)." A system of four arithmetic operations has been made by a shift in the numerical group.

However, when a shift in the numerical group becomes difficult as numbers become bigger, Fujisawa's handwritten calculations appear. As a previous step of addition by handwritten calculations, mastering mental calculation is necessary. Then, he explains about addition by handwritten calculations, but it seems that he paid no attention to any explanation of rounding-up. Subtraction is a subtraction of the general integer. He then explains about the cases of rounding-down, without-rounding-down and having a decimal number. As for the cardinal numbers and the multiplier of cardinal numbers, he uses multiplication tables. He explains that the rest is in the following order: that a multiplier is a cardinal number; that it has some zeros to the right of significant figures; and that it is a general number. He explains about division separately in the case of cardinal numbers and of double figures. He attempts to eliminate quantity allocation dogmatically from a system of numbers and calculation that

is systematized according to ordinal numbers.

However, though not to be mentioned, we cannot eliminate the quantity from our daily livings. It may only be only said that from his viewpoint, there was no successful example of a method by which he could explain the relation between number and quantity without having used dogmatic manner at that time. For the reasons stated above, the numeration principle of Rikitaro Fujisawa has been regarded as limited due to a lack of a decimal structure. He also criticized theoretical arithmetic, which was practiced mainly by Hisashi Terao, imported arithmetic teaching since the Meiji Period, and the arithmetic in the Sanzendai-style (repetitive learning style), which was a difficult problem in competitive examination.

3. Enumeration Principles of Tanc and Knilling in German

The enumeration principles of Tanc and Knilling in German, which are mainly enumeration principles since a number diagram was introduced, will be organized here. As mentioned by Rikitaro Fujisawa, the enumeration principle originally started after being inspired by the book of Tanc and Knilling who were influenced by German psychology at the time. In time, Knilling changed his idea and positively evaluated a number diagram so that it came to be called the “intuitionistic enumeration principle” by Fudetaro Suzuki.

4. Knilling’s Idea Soon Came to be Differentiated from that of Tanc’s

I’d like to present here that the idea of an “increase or decrease by one” or an “increase or decrease by two” is a form of teaching practiced by the editors of the so-called Green Cover Textbook. We may be able to think that this would be evidence that the “enumeration principle” of the so-called Green Cover Textbook had entered the stage that is apparently different from what Knilling and the first government-designated textbook being used to teach. Today, there are some textbooks that have adopted this idea in Japan. In addition, the above-mentioned Green Cover Textbook deals with number factorization rather than swiftly proceeding to the addition and subtraction method. That is, it started from counting, deals with a number figure, and proceeds to number factorization. This is an aspect not seen in the first government-designated textbook, but seen in the Green Cover Textbook for the first time. Its number figure does not attempt to make us understand numbers by array. Numbers are always the object to be counted. Consequently, it does not aim at our grasping numbers through an array of circles as Bates and others do. Therefore, although the Grube method was adopted in Japan, the fact that intuitionism itself was ever practiced has not been established.

On the other hand, the enumeration principle of Knilling can be also regarded as intuitionism in a sense that it positively has accepted a number figure. The aim of arithmetic teaching is seen in the attitude that compromises between the conventional regular computation method, the formal selection method, and the objective computation method. Selection and array of teaching materials deal with pure and clean numbers with respect to the technical calculation that mainly aims at the mastering of calculation. As for its practical calculation, it has dealt with realistic problems, and has been a help in our daily life. Besides, regarding its scientific calculation, it has to interest children in as many and various fields as possible. It has made one rule in principle to the point of spontaneous pausing, which is contrary to Pestalozzi’s orderly method for learning four arithmetical operations and Grube’s multidirectional handling method. The teaching method adopts the three-step theory against the injection formula of the regular computation principle, Pestalozzi’s intuitional introduction of the number figure, and Herbart’s methodology with five formal steps. Below we have categorized traditional views as to what the

number is. “The number stands outside the object, and transcends the object. The number is ingenerable, imperishable, and invariant. The number is the root of the object.” The number is one of the attributes of the object just as the color and the form are also attributes of the object.

Therefore, the number exists in reality, but it does not exist on its own. Rather, it has the nature to attach itself to the object. “The number does not exist independently, nor does it have the nature to attach to the object. It is rather just a form in which people perceive the object and make others understand. Accordingly, the number is a purely subjective thing, and any actual thing corresponding to such a subjective form does not exist in the external world.” “The number is equal to the object, and it means many objects.” According to this classification, the ideas of Kronecker and Rikitaro Fujisawa correspond to the third, but the idea of Knilling might be expressed as an objective concept mixed with the third and the fourth. This has proved the fact that both concepts cannot exist separately but are combined by actuality, in which psychological implication has been denoted. Knilling thinks that at least an objective concept and rational concept are required for the generation and formation of the number concept. A number as an objective concept requires factorization such as: “in a word, extracting and distilling from a combination of sense and perception.” He thinks that number as a rational concept requires a combination of “mental action to summarize and integrate”, and that the number concept is formed with two such factors, and has defined and classified the number concept.

Classification in the past has two different views of concrete and abstract number, and does not present other different kinds of number. As for the classification for the constant and inconstant numbers, he thinks that this classification is not right and that only the constant numbers exist because the numbers itself has been determined. From this point of view, the constant numbers are classified into the main numbers and the sub numbers. A main number is classified into “a number of natural unit”, “a number of measurement unit”, and “a mathematical and philosophical number”, and a sub number into “an ordinal number”, “a number that presents logical chaos”, and “an operand”. From the above, we can clearly see that Knilling realizes actual quantity, and his idea is different from the enumeration principle of Rikitaro Fujisawa from which he has dogmatically adopted a relation between number and quantity.

Next, the issue of how the number concept can be obtained becomes important. To obtain the concept, Knilling needs the “number intuition”, “number notion”, “way of counting”, “number system”, and “calculation”. As for number intuition, he accepts intuition as the same concept as the one that Pestalozzi has mentioned. However, he places a number figure used by intuitionism between quantity and number, and utilizes it for the purpose of supporting the idea of intuition. The number notion has been classified into the natural number notion and the artificial number notion. He remarks that the former is a concept that is intuitionally generated only by our sensible perception, and that we neither think correctly nor memorize even in our notion. He points out how difficult it would be to teach arithmetic because we cannot be satisfied with only a superficial notion. The latter is generated based on counting, and it is substantially different from the natural notion, which also positively accepts a number figure.

Next, Knilling insists that the way of counting as a process to discover the number has been developed through three steps. First, as a way of counting by visual measurement, he introduces an experiment described in “Child’s Spirit” by Pleyel. A child aged two years and five months places nine kegel balls one by one while counting “one, one, one, one, one, one more, one more, one more, and one more”, which is an action done with objects by objects. However, this is not sufficient, so the way of counting on the fingers has appear in the next step. In the way of counting by visual measurement, numbers more than four are ambiguous, and the child has to

put the fingers of both hands on the object one by one in order to realize the number such as five, six, seven, and so on. Knilling points out that the etymology of numeral is grounds for the child to respond.

Next, Knilling explains about the way of counting with words. He thinks that something that used to be subject to the one counted with the fingers has taken the center stage this time. Also, since the number concept cannot be obtained just by counting, decimal numbers are required. The number system has been developed from the stage where the number was counted with the fingers, but he regards that it will make it possible to calculate bigger numbers surely in a short time. Knilling also thinks that the number system is the method by which to create the number concept as well as the method to create the name of any number that could describe all decimal numbers with ten Arabic numerals.

The numeration principle of Rikitaro Fujisawa has thought that calculation is an operation in the number system, and it includes a double idea. He criticizes that one neglects the number system, and the other starts to count from the first after corresponding to the reality. As mentioned above, he says that the number concept is obtained by the number line, the number concept, the way of counting, the number system, and calculation. However, any relation between the number line, the way of counting, the number concept, and calculation is still evaluated to be ambiguous.

The enumeration principle is backed up by the time system, and intuitionism by space. As for the number range as a teaching material, it says that it should be determined by valid psychological rules concerning the whole of arithmetic teaching. For instance, 5 is the natural limit when counting with one hand and up to ten with both hands. Namely, the numbers that are obtained from a combination of ten and a/the cardinal number are from eleven to twenty. We can define up to 100, that is ten times more than ten when we count by setting ten as a unit, up to 100 when we count by setting a hundred as a unit, and up to 1,000,000 by multiplying 1,000 by 10,000 when we count by setting a thousand as a unit.

In addition, he has used a calculating board in order to help others intuitionally understand number and calculation in the number range of 1–20. After all, the enumeration principle of Knilling is different from the one of Rikitaro Fujisawa. However, despite pointing out the limitation of using the number figure, it may be proper to say that it should be evaluated as incomplete because its viewpoint on the number concept does not necessarily coincide with actual teaching.

5. The First Government-Designated Textbook and Enumeration Principle in Japan

It is said that the first government-designated textbook had a strong influence of Rikitaro Fujisawa and has been directed by his idea regarding the teaching concept, method, and contents. However, the contents also include a psychological examination of children. His enumeration principle rather lacks a psychological examination. Consequently, it can be thought that even if there were some influence, not all his notion has been reflected in it. The selection of the number range in the first government-designated textbook is similar to the enumeration principle of Knilling.

However, it is difficult to judge the teaching target of an actual class at school because actual teaching was delegated to each teacher separately from the arithmetic textbook. As described in the guide book, at first, teachers voiced the numeral, and then instructed students to understand a mass of a collected set as a number by counting in the class. This is what has been valued as a characteristic of enumeration principle. The order of counting goes from concrete to abstract. The actually used order has also become a medium to move to abstract. For this reason,

it utilizes actual things different from the way of Rikitaro Fujisawa.

In that sense, the first government-designated textbook basically focuses on teaching concerning addition, but it does not necessarily depend only on the counting-down method by positioning subtraction as a back calculation of addition. In fact, typical guidance methods of enumeration principle appear now and then in the writing of Takeshi Sato. He starts from voicing, and shifts to counting. Those being taught first voice abstract numbers, and soon they shift to counting by adding counter suffixes such as “piece”, “stick”, “head”, and “person” to numbers. Any number figure is not used here, but circles or black circles are used as objects.

However, the only one who has touched on that point is rather Hisao. In the first government-designated textbook in Japan, the same method is applied to “4+3” and “4+2”, and there is no room where intuitionism plays any role. It is pointed out that the enumeration principle is addition and subtraction calculation, which has taken advantage of the number system, and eventually, it has a characteristic of describing the size of the number by the voiced numeral.

6. Conclusion

The numeration principle of Rikitaro Fujisawa, a mathematician, started from mathematical theory and then created the system of rational number by ordinal number. The counting method is an operation in the number system while explanation of the decimal structure is only how to voice it, so it lacks psychological examination. In that sense, it is apparently different from the numeration methods of Tanc and Knilling. The numeration principle of Knilling started from a German psychological examination that was conducted of that time. The way of obtaining the number concept is counting by transcending intuitionism, and it will shift to number calculation through memorizing the result of counting and by understanding of the decimal structure. It appears as a psychological enumeration principle, and there is something to be noted as to the limitation of the number range and the development of teaching materials according to the teaching principle of “natural and appropriate teaching”.

The first government-designated textbook in Japan is tied in with children’s lives regarding the degree of completion and its intention. It is appropriate to evaluate this from the viewpoint of unit learning for daily life. For example, there are those who positively took advantage of the enumeration principle regarding calculation technique such as Takeshi Sato. The criticism of those who study arithmetic for life is against the viewpoint of thinking from number to quantity, which has been adopted by the first government-designated textbook in Japan. This attitude, which focused on quantity, has created the present multiplication tables and has come to be posted in the third government-designated textbook in Japan. The first government-designated textbook has adopted the conventional multiplication tables influenced by Japanese mathematics in the Edo Period.

In addition, Yasujiro Ando adopts number factorization as a principle of addition and subtraction in the Grube principle. Although number factorization is not always easy for children, we can appreciate that there is an important meaning in arithmetic education, which has existed in the history of mathematics since the Meiji Period, and which would lead to the actual teaching method made with the present textbook in Japan. Conventionally, there has been an opinion that the enumeration principle of Rikitaro Fujisawa and the one of the first government-designated textbook are the same, but this manuscript has a different opinion from that. In addition, the existence of Fudetaro Suzuki, who has actually not been spotlighted for many years in the past, was also able to be presented.

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