IMPROVING MATHEMATICS LESSON STUDY: WHY JAPANESE TEACHERS USE DART GAMES FOR THE INTRODUCTION OF AREA LEARNING

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The research style "lesson study" has now been broadening over the world as a method for improving the quality of mathematics lessons. However, principles of lesson study such as objectives, content, and method have not been investigated. As a result, lesson study seems to be treated arbitrarily by people who are engaged in it, with the impression that lesson study is rather difficult or profound. This paper tries to illustrate what lesson study really is and does, by considering the introduction of area learning (4th grade), and the essence of lesson study. Moreover, it addresses the issue of current mathematics education, and mathematics lessons, in order to improve them. That is, it addresses the objective of mathematics education, and the relationship between the objective and the method of teaching mathematics.

INTRODUCTION

The research style "lesson study", which started in Japan, has now been broadening around the world, as a method for improving the quality of mathematics lessons (Stigler & Hiebert, 1999). This would indicate that people have begun to recognize the importance of considering mathematics lessons themselves. However, it seems that there has not been an essential discussion about what lesson study is and does. In other words, we have not discussed seriously this matter of improving mathematics lessons. Lesson study is planning a lesson, observing the lesson together, and then discussing it. However, principles such as objective, content, and method have not been investigated. As a result, lesson study seems to be treated arbitrarily by people who are engaged in it, with the impression that lesson study is rather difficult or profound.

If we wish to actually improve and deepen our mathematics lessons, we should focus on and discuss the matter of what lesson study is. Japanese lesson study needs to be analysed academically and described plainly to others.

This paper considers the introduction of area learning (4th grade) in order to illuminate what lesson study investigates, and in addition, discusses the essence of it.

APPROACH TO A MYSTERIOUS LESSON STUDY

Why Japanese Teachers Use Dart Games for the Introduction of Area Learning

Generally, primary 4th graders learn the basics of area concept, which is the Japanese curriculum standard. Children acquire the concept of area through mathematics

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learning, which covers the thinking of “width”, which is used by them in daily life. It means learning that “width” (or area) is a quantity showing how many unit areas are included.

So why do Japanese teachers use dart games to start this learning? Perhaps most researchers and teachers would not understand it and would see the lesson as mysterious. Of course we can understand lesson study through observing an actual lesson and then through lesson reflection, however, lesson study needs to be analysed and proposed clearly to others.

THE CHANGE OF INTRODUCTIVE PROBLEMS ON AREA LEARNING IN JAPAN

A Representative and Introductory Problem Which had been Used in Japanese Schools for a Long Time: Comparison of the Area of a Square and the Area of a Rectangle

In Japan, the problem as follows had been used as an introductory problem for area learning for a long time (1961-2001): [Problem 1] Let’s compare the area of a rectangle with the area of a square below (Figure 1).

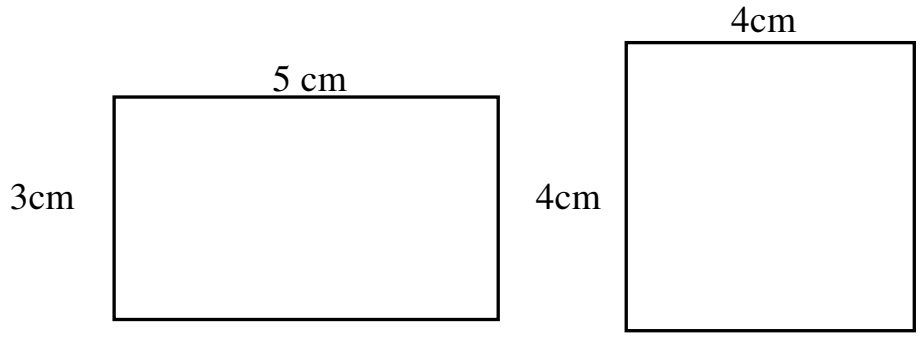

Figure 1: An introductive problem.

As shown here, the perimeters of the rectangle and the square are both 16cm. The fact that the perimeters are the same in this case, is the point. Firstly, children judge area intuitively first after looking at two shapes. Some think that the rectangle is bigger and others the square. However, the judgments are made by just looking at the shapes, and often there are children who think both shapes are the same area. Being asked why, they answer, “Because the two perimeters are the same.” Children tend to think that shapes with the same perimeters have the same area. This is naïve thinking and a misconception of area.

Secondly, children manipulate the two shapes, for example, they begin to compare the shapes passed out on printed papers (see Figure 2), and they become aware that the two shapes have different areas.

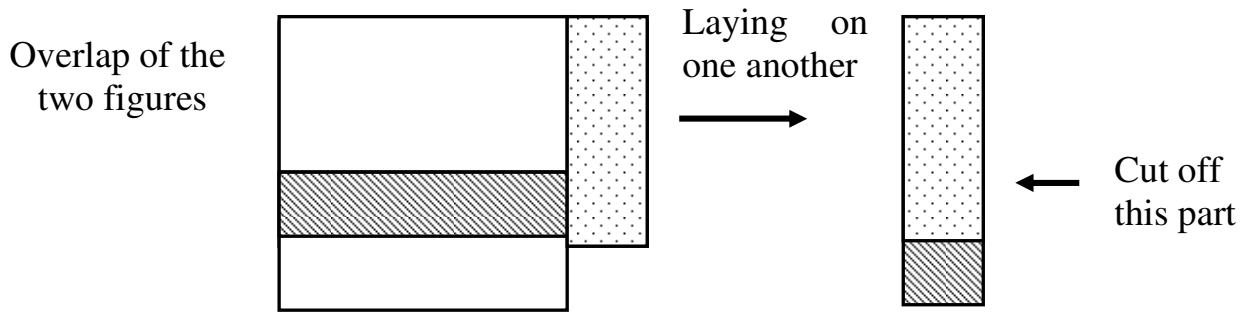

Figure 2: A sample of children's manipulation.

Through this manipulation, children will become aware that the two shapes which at first seem to have the same area, are not the same: the square is bigger. Furthermore, they will notice that the square is bigger by the shaded portion. However, this manipulative activity is not a final goal in this lesson.

Thirdly, the textbook moves on to teaching the children that they have to compare the two shapes on 1cm graph paper. That is, the lesson requires that children compare the shapes by how many squared sections they consist of. Then, teachers introduce the idea of a unit area into the mathematics lesson.

Why had this problem been used as the introduction of area learning in Japan for such a long time? It seems that in Japan dozens, or perhaps hundreds, of research lessons had been done using this problem: a research lesson being a lesson that is done especially and systematically in order for the teacher to improve mathematics lessons in school. Japanese teachers had thought that this introductory problem was very effective, but, it became clear that Japanese teachers did not attach greater importance of teaching children the idea that the total area of a shape can be measured by the number of unit squares.

The Issue on the Lesson Using This Problem

Problem 1 stands by itself, however Masaki (2002) wonders about the validity of the problem. He claims that there is no reason for comparing the areas of the shapes. Certainly that is true. He insists that children do not need to solve this part of the problem, because it is different from their natural thinking. Therefore, a new introductory problem was devised through many research lessons. It is a "Zinntori-game", which is a game to capture territories, and was adopted into textbooks.

The Introduction of Zinntori-game after the Comparison of Areas (2002-)

The present Zinntori-game used for the introduction is as follows (Figure 3).

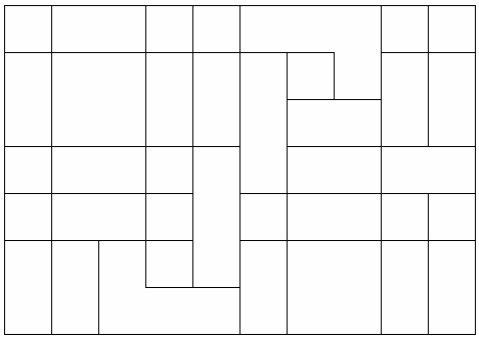

Figure 3: Zinntori-game.

In this game, the player who wins rock-paper-scissors can take a territory of a rectangle or a square and so on. If one wins rock-paper-scissors, one can take a territory, and the next player can take a territory close to it. When all the territories are taken, the game is over. The way to win the game is to take more territory. Therefore, players need to think about and calculate the territories that they took (see Figure 4).

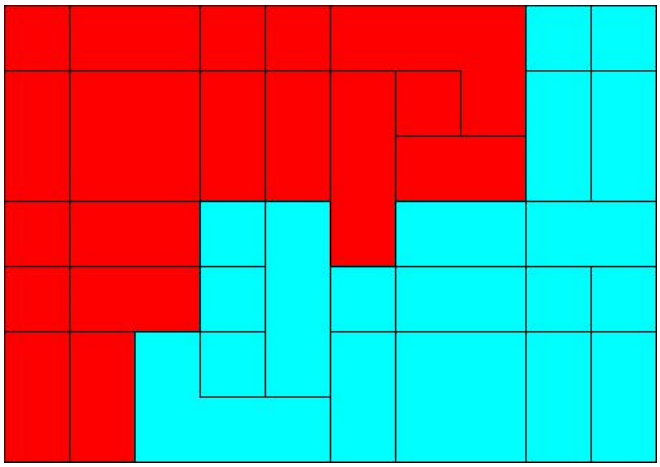

Figure 4: An example of finished Zinntori-game.

In this game, if each territory had the same shape, there would be no problem. However, there are various quadrangles with different areas to solve, and in addition, L-shaped figures. So, children begin thinking about which player has a larger territory. How can they compare the area of territories that they took in this game? There are not many children who will not notice the smallest unit on the board. They should not compare their territories by the larger shapes. Therefore, the idea of using the smallest unit to compare the total area of their territories will be found by the children themselves. That is the teacher's intent, that the children find this out on their own.

There are other Zinntori-games to use besides the above game (see Figure 5).

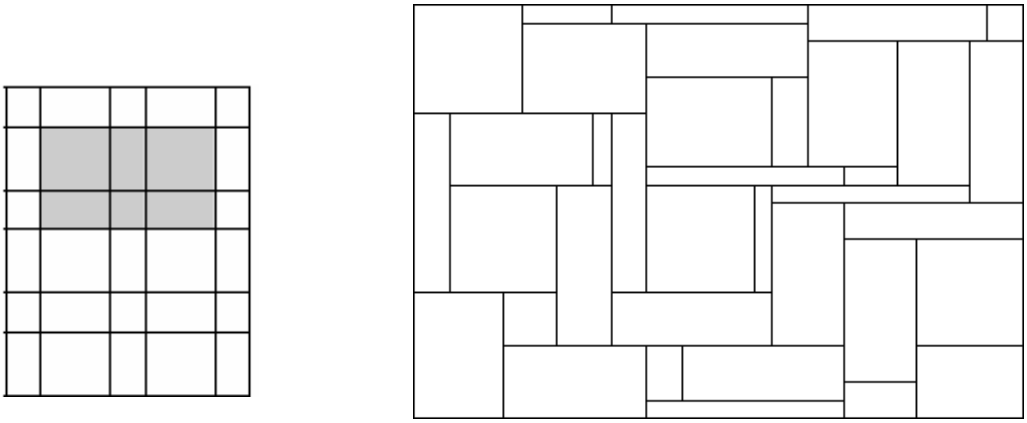

Figure 5: Other Zinntori-games.

With the left Zinntori-game, it is easier for us to grasp how to think of a unit area. On the other hand, the right game is more complex. Many other kinds of Zinntori-games have been thought of and practiced, such as games with different shapes or different ways of capturing territories. In addition to these, presently there are other Zinntori-games that use geo-boards or computers, not just paper. Japanese teachers have thought of many kinds of Zinntori-games, and they continue to investigate how they should best introduce area learning.

The Issue on the Lesson Using This Game

When we do this lesson, we find that it takes a lot of time for the game. Children take a while to understand what exactly they are learning. While they play the game, they do not yet understand they are doing so in order to grasp the concept of area. Through these activities, the teacher tries to make children understand the necessity of a unit area.

Regarding the issue of this problem, Kasai (2002) states that the Zinntori-game makes children aware of area in the beginning, which is paradoxical. This means that to teach children "area" the teacher should not at first make them aware of it. The aim is to allow children to become naturally aware of area. Such thinking in mathematical lessons is particular to, and in a sense it may be an essence of, Japanese lesson study. In other words, the teacher does not teach what she/he wants the children to learn, rather, she/he hopes that children will be able to find it out heuristically, and that such a lesson is the most valuable. Japanese lesson study is based on children's self direction not teacher-centred, and therefore, the phrase of "children themselves spontaneously" can be very often seen in Japanese teachers' papers. This trend might be different from other countries. The Japanese way of mathematics learning can be called a kind of constructivism, which is known as social constructivism.

The Introductory Lesson of Area Learning Using Dart Games (recent)

Finally, we will consider the introductory problem of area learning using dart games. Through the above argument, you may guess why Japanese teachers use dart games for the introduction of area learning. To supplement the defects of the comparison of the areas of the square and the rectangle, or the Zinntori-game, Tsubota (2003) proposed his own lesson. He presented the introductory problem using dart targets as follows (Figure 6).

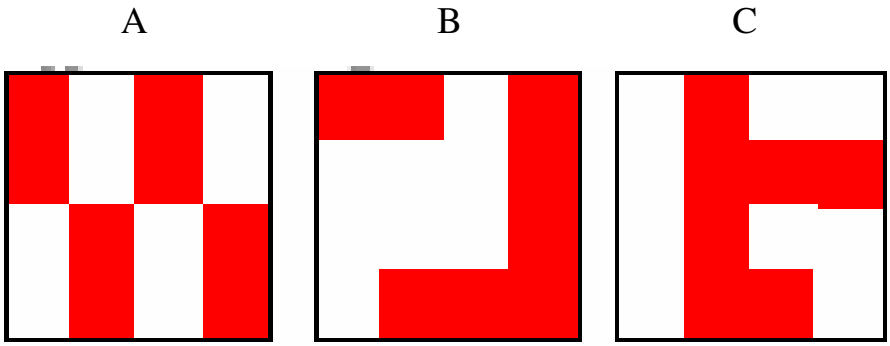

Figure 6: 3 targets of dart game given by Tsubota.

At first, he presented children the target A, and they tried to hit the target with one dart each. If they hit the red part, they had to sit on the left side of the classroom, and if the white part, they had to sit on the right side. Eventually, half the children sat on the left, and on the right. The lesson went well and the darts were divided between red and white parts.

Next, Tsubota presented the children targets B and C, and asked them why he did not use these targets first. Regarding which colour (red or white) is easier to hit, each child held different opinions, and they discussed their opinions with each other. In fact, the target B has the same area in red and white parts, and the target C has a larger white part. Since they cannot see the certain difference among targets, they investigate the question: which is bigger? That is, it is necessary for children to learn the area of the red and white parts of the targets B and C themselves. In other words, the children begin to grasp the idea of area on their own. If the teacher leads children to grasp how many unit areas a figure consists of, the lesson would be easier for them. However, Tsubota did not do so.

Tsubota used a dart game as a teaching material for children to be able to think of unit area naturally. Therefore, the advantage of this lesson is not that the teacher tells the children the concept of area, but that the children can acquire the concept naturally. It is not too much to say that he pours all his energy into this point. Presently, this lesson by Tsubota is praised as one of the most excellent lessons in Japan. It is because he created a new teaching material by applying dart games to area learning. It is important for the teacher to create new mathematical lessons or teaching materials.

WHAT IS IMPROVING MATHEMATICS LESSON STUDY?

The above statements introduce a part of Japanese lesson study as a sample of the introduction of area learning in 4th grade. These mainly deal with the issue regarding the introduction of a lesson, but lesson study includes other issues. For example,

- Coming up with teaching material and posing problem (introduction)
- Coming up with lesson development (solution by themselves, working it out)
- Instruction to improve children's mathematical expressions
- Instruction to make children acquire mathematical basics
- Instruction to foster children's communication ability
- Construction of the unit, etc.

This paper focuses on only coming up with teaching material and posing problem. In addition, the teacher should study the many matters that come up in lesson development daily. It is very important for us to know why Japanese teachers use dart games for the introduction of area learning. It is related to the essence of Japanese lesson study. That is, they do not aim in the lessons to just give children mathematical knowledge and skills. These problems were developed considering the question of how the teacher should teach children the concept of area seriously. In other words, they try to teach mathematics lessons close to the essence of mathematics and strive to have children acquire creative abilities. Therefore, we can say that the objectives in Japanese mathematics education are very high. In a sense, it is likely to foster a little mathematician. That is the thinking and method that Japanese lesson study is based on. The objectives of lesson study focuses on how children do math, therefore, Japanese teachers come up with lesson construction based on that.

CONCLUSIONS

Mathematics lesson study has been used all over the world, and it is very pleasing that this research style has spread widely. However, we have many things to arrange and illuminate in order to foster children's mathematical abilities and improve teacher's teaching abilities.

First, it is necessary that teachers and researchers around the world know the worth of "lesson study" and, in addition, try practicing lesson study. There are certainly some points that people cannot understand without actually doing.

Secondly, we need to try to academically systematize lesson study. Presently there are many fuzzy aspects in lesson study and therefore it depends on phenomenological research style. To complement such faults, there needs to be the establishment of a method for analysing lessons. Through such a method, the discussion of lesson study will deepen more and more.

Thirdly, it is necessary that we should consider what is improving mathematics lessons, exchanging good mathematics ideas. Furthermore, we teachers and

researchers need to consider that matter and broaden our results. Then, some cultural and political matters might occur, relating to the movement of lesson study. However, no matter what problems may come, we should open our lessons to the public and criticize them with each other, because our concern is to improve our mathematics lessons and revise them. This is literally the essence of lesson study. Observing a mathematics lesson, the teacher and researcher exchange their opinions with each other and improve our lessons. These activities should be developed globally so that lesson study may take a new turn in the world.

Fourthly, the most important thing is that we should try to answer why (or for what) we teach children mathematics, and from the children's side, why (or for what) they learn mathematics. It is natural that the answers to these questions are related to how to teach mathematics and how to learn mathematics. We should consider mathematics education from this radical question and lesson study is part of that.

Lesson study itself may have just been born from the worldwide point of view, but it has possibility to grow in size and content. That is, lesson study is a very dynamic activity, which changes not only mathematics classes but also our world.

References

Kasai, K. (2002). Menseki no dounyuu zyugyou de subarasii to omotta ten. [The points that I felt the introductive lesson of area learning great.]. *Elementary Mathematics Lesson Study*. 21, pp. 12-13. (In Japanese)

Masaki, K. (2002). Hirosa ga miete kuru zyugyou. [A lesson that "width" appears in front of children.]. *Elementary Mathematics Lesson Study*. 21, pp. 10-11. (In Japanese)

Stigler, J.W., & Hiebert, J. (1999). *The teaching gap: Best ideas from the world's teachers for improving education in the classroom.* New York: The Free Press.

Tsubota, K. (2003). *Sansuu tanosiku zyugyou zyutu.* [A method how to teach elementary mathematics interestingly]. Tokyo: Kobunshoin. (In Japanese)