Ogata, H. et al. (Eds.) (2015). Proceedings of the 23rd International Conference on Computers in Education. China: Asia-Pacific Society for Computers in Education

Comparative Studies of ICT Used in Mathematics Education in Japan and Other East Asian Countries

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Abstract: This is a comparative study of the Japanese and East Asian use of information and communication technology (ICT) in mathematics education. In Japan, the concern with ICT has been growing for the last several years. The question we ask here is what should be done to use ICT more effectively in mathematics education. We investigated the mathematics textbooks used in East Asian countries. The investigation showed that in Singapore and Vietnam, function calculators are used effectively beginning in elementary school. Japanese textbooks have to be treated reality values. If students treat reality values they need to use a calculator. There is a possibility to expand applied mathematics in the field.

Keywords: Mathematics education, East Asian countries, Function calculator

1. Introduction

There are two international achievement tests in mathematics. One is Trends in International Mathematics and Science Study (TIMSS), and the other is the Programme for International Student Assessment (PISA). The former is an achievement test concerning mathematical contents, and the latter is an aptitude test concerning applications of mathematics. In the past, the countries with high-ranking scores on the TIMSS have been East Asian countries, and in years, this has been true of the PISA ranking as well.

TIMSS 2011 and PISA 2012, Singapore was ranked in the first and second place, respectively, and Vietnam was ranked in 17th place in PISA 2012. In addition, Vietnam's rank of International Mathematics Olympiad (IMO) 2013 was above that of Japan.

In both countries, students use function calculators starting in elementary school. The mathematic textbooks teach math contents on the assumption that function calculators are used. In this study, by analyzing the mathematic textbooks used in East Asian countries, we clarify the characteristics of the use of function calculators. The purpose of this study is to compare and examine the desirable use of ICT in mathematics education.

2. ICT Use in Japan

2.1 The present situation

The syllabus edited by the Ministry of Education in Japan includes several important statements on ICT. Let us take the General Provisions for example: "When teaching subjects etc. , each school should improve learning activities so that pupils become familiar with information devices, such as computers and information and communications networks, acquire basic operation skills, such as typing letters on a computer keyboard, and information ethics and are able to use information devices appropriately. In addition to these information devices, each school also uses other teaching materials and aids properly, such as audiovisual materials and teaching and learning devices." Moreover, concerning mathematics, "In teaching the content of each area, consideration should be given to properly using tools like *Soroban*

(Japanese abacus), calculators, computers, and information and communication networks as needed in order to improve the learning results. This should especially be taken into account for the instructional content related to numerical calculations, as well as in teaching through activities like observation, manipulation and experimentation." In summary, the use of ICT in mathematics education is specified in the syllabus.

However, the question we have to ask here is what should be done to use ICT more effectively. First, we will focus on the current use of ICT in mathematics classes. Table 1 shows the results of the investigation of computer use in mathematics lessons in the second year of junior high school, according to TIMSS 2011. The investigation in Vietnam is not the subject of this study. We see from Table 1 that the points awarded for ICT in Singapore and Korea are above the international average, and compared with many foreign countries, ICT use in Japan is an extremely low. Moreover, in TIMSS 2011 and PISA 2012, Singapore and Korea ranked higher than Japan.

Next, we will focus on the present situation. The concern with ICT has been growing for the last devices have risen. Among elementary and junior high schools, the use of electronic whiteboards has spread to above 75%. Further, it is quite likely that electronic whiteboards be installed in all the schools. Tablet-type devices are distributed to each student in some schools. It has been reported that tablet-type devices are more widespread in schools in Korea.

However we raise some concerns about the effective use of ICT in mathematics education in Japan. We will take up this problem in Section2.2.

Table 1: Computer use in mathematics lessons (in the second year of junior high school)

	The ratio of students who are taught the following using computers in mathematics lessons, at least once a month (%)			
	To search for mathematical principles and general ideas	To examine ideas and information	To process and analyze data	To practice skills and logic
Japan	3%	5%	6%	1%
Korea	32%	30%	25%	28%
Singapore	38%	26%	24%	34%
International average	22%	23%	21%	24%

2.2 Case of Japan

We will examine cases of ICT use in Japan. In the past, students used calculators for some teaching materials, but they were not as highly-efficient as function calculators. Even when students used calculators in mathematics lessons, they were usually general calculators. From the view point of the field of education, one may say that "calculators" equal general calculators. Then, the use of calculators in mathematics education was specified in the syllabus. The textbook included the problems for which students could use calculators. However, almost all the problems could be solved by hand. Today, Japanese teachers have the choice of allowing students to use calculators or not, but as I mentioned in the previous paragraph, the usages rate is low. Japanese teachers tend to disapprove of the use of calculators in mathematics lessons. One of the causes of their resistance is the Japanese examination system, which does not permit students to use calculators on the exam. Thus, students need to do hand calculations quickly and correctly to pass the examination. In addition, we think that another source of the low usages rate is school hours. It has been reported that number of school hours dedicated to mathematics in Singapore is about twice that in Japan. We can say that Japanese teachers do not have enough time to use ICT containing calculators.

Even though teaching materials have been developed for the use of calculators, the actual rate of use of calculators is not widespread. We must now return to the issue that we mentioned earlier. As pointed out, we raise concerns about how to use calculators more effectively in mathematics education. It is clear that the use of electronic whiteboards and tablet-type devices has risen. However, in most cases, the use of these tools improves only the visual from of mathematics problem presentation. Figure 1 shows a student using an electronic whiteboard. This figure is a good example illustrating ICT use. The electronic whiteboard only shows the contents of the textbook. The word problem is the addition of

two decimals, “0.5 + 0.3.” The question we have to ask here is “Is it necessary to use ICT in this case?” The problem we have to consider next is what seems to be lacking in constructing mathematical contents. The same thing may be said of the use of tablet-type devices.

We agree with the introduction of ICT in schools. Yet we disagree with how to ICT is used in the present situation. What must not be forgotten is that the calculators with teaching materials designed for their use remains uncommon in school. It is quite likely that ICT tools may simply duplicate the potential use of calculators. It should also be noticed that there was a time when Japan actively utilized ICT in mathematics education. Former mathematical textbooks contain Graph drawing or matrix equation calculating which are frequently used for getting an approximate value, and they are a lot of explanations about how to use various equipment such as calculator, computer etc. But, they are almost deleted in the current textbooks.

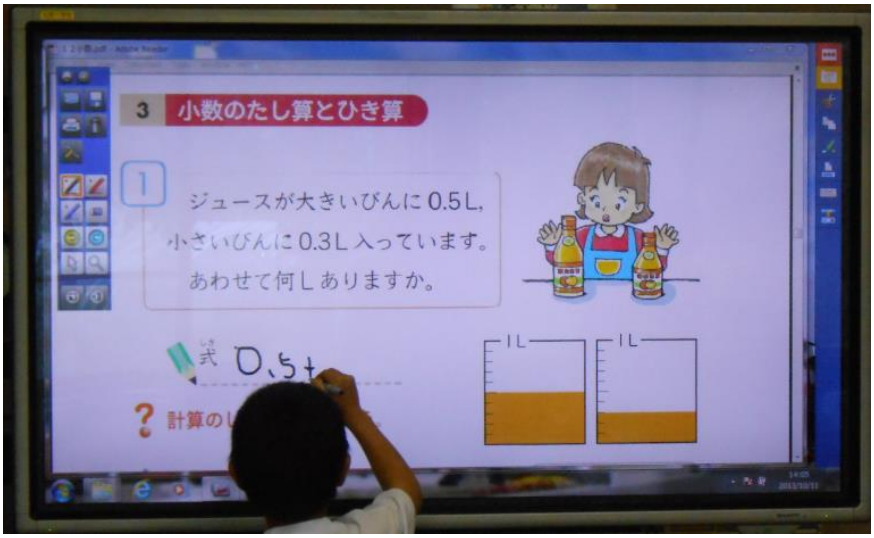

Figure 1. The use of an electronic whiteboard for practicing mathematics problems.

3. ICT Use in Other East Asian Countries

3.1 Case of Singapore

The Ministry of Education in Singapore shows the following seven contents about “Skills.” Numerical calculation, Algebraic manipulation, Spatial visualization, Data analysis, Measurement, Use of mathematical tools, and Estimation. In summary, the ICT used in mathematics education is spelled out in the syllabus. Let us examine the “Use of mathematical tools” in more detail. In this article, except in regard to function calculators we are not concerned with ICT.

In Singapore, the function calculator is used starting in fifth grade in elementary school. There are the units on how to use the function calculator in the textbooks. Using function calculators is allowed with complicated calculations for which general calculators are insufficient: e.g. a mixed fraction, the cubic root, four arithmetic operations, etc.

The case is similar, in junior high school. Concrete examples are shown in Figure 2: the piled up radical roots and indices of high degree, etc. It is impossible for these problems to be solved through hand calculation. The problems for which students use function calculators are not only algebraic, but also geometric. Trigonometry and Radian Measure are taken up in the third year of junior high school. One of the notable features of their units is unlimited angles. Unlike in Japan, students only use typical angles (30, 45, 60, etc.). Figure 3 is textbook in Japan, Figure 4 is one in Singapore. By comparison, it is clear that both textbooks are contrasted from treated complex numerical calculations viewpoint. If students treat reality values they need to use a calculator.

Judging from this, the problems for which function calculators are used connected with real phenomena. On the other hand, the textbook in Japan has no relevance at all to the real phenomena. The cause of these is the prejudiced leading which is hand calculate and deformation.

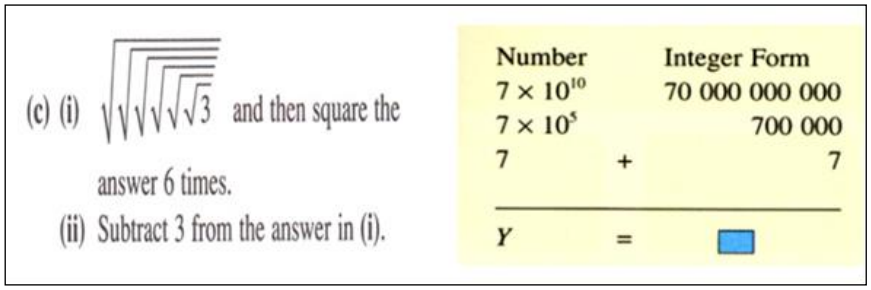

Figure 2. Example problems for which function calculators are used.

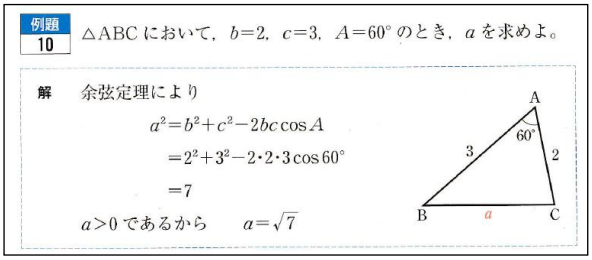

Figure 3. Example of the cosine theorem (Japan)

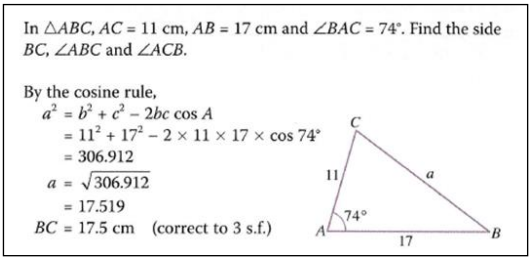

Figure 4. Example of the cosine theorem (Singapore)

3.2 Case of Vietnam

In Vietnam, each student buys his own function calculator in the upper grades of elementary school. They begin using calculators in earnest in junior high school. In his study, Matsuzaki (2014) mentioned the following characteristic of mathematics education in high school: "The students always use function calculators in the class." In Vietnam, they are permitted to use function calculators on the entrance and final examinations for high school and university. Therefore, we consider that it is possible to use calculators in mathematics education.

Trigonometry is taken up in the third year of junior high school, as in Singapore. They do not use typical angles. A concrete example is given in Figure 5, where students have to find the value of sin54. To solve this problem, the students should use function calculator because the value of sin54 is too complicated to calculate on hands.

When the unit of a quadratic equation is treated, students use function calculators, too. An example that the unit is the estimation of the answer to the equation. The estimation is done by substituting an optional number for the equation. In the case of a discriminant, the students calculate *D* using function calculators as these impossible problems cannot be solved through hand calculation. Compared with Figure6 is textbook in Japan, Figure7 which is textbook in Vietnam has a complicated value.

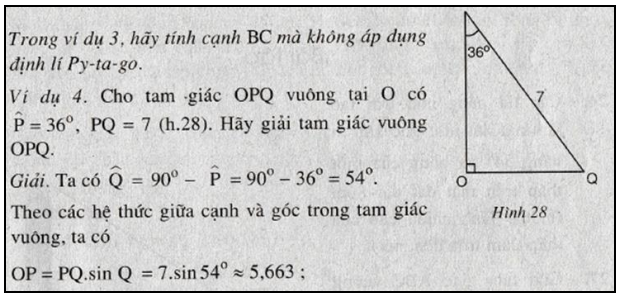

Figure 5. Example problem using unlimited angles.

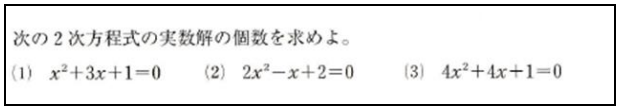

Figure 6. Example of discriminant (Japan)

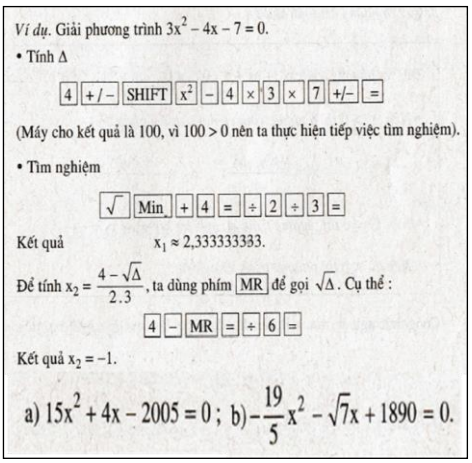

Figure 7. Example of discriminant (Vietnam)

4. Conclusions

In conclusion, we would like to state the following three points.

- In Japan, ICT use in mathematics education is specified in the syllabus, but compared with many foreign countries, ICT use in Japan is extremely low. In addition, the example cases of ICT use are remarkable to improve the method of education, but the contents of education are still the same.
- In Singapore and Vietnam, each textbook is edited on the assumption that it will be used with a function calculator.
- The characteristics of the use of function calculators show that a distinct line is drawn between human ability and the technology component.

A further direction of this study will be to design more concretely how to utilize ICT in mathematics lessons. It is for this purpose that we suggest the cycle of the process to solve problems in mathematics. The model of this cycle appears in Figure 8. The cycle draws a distinct line between human ability and the technology component when students acquire mathematical abilities. Finally, we think that the desirable use of ICT in mathematics education comprises lessons following the cycle of Estimation, Operation, Result, and Inspection.

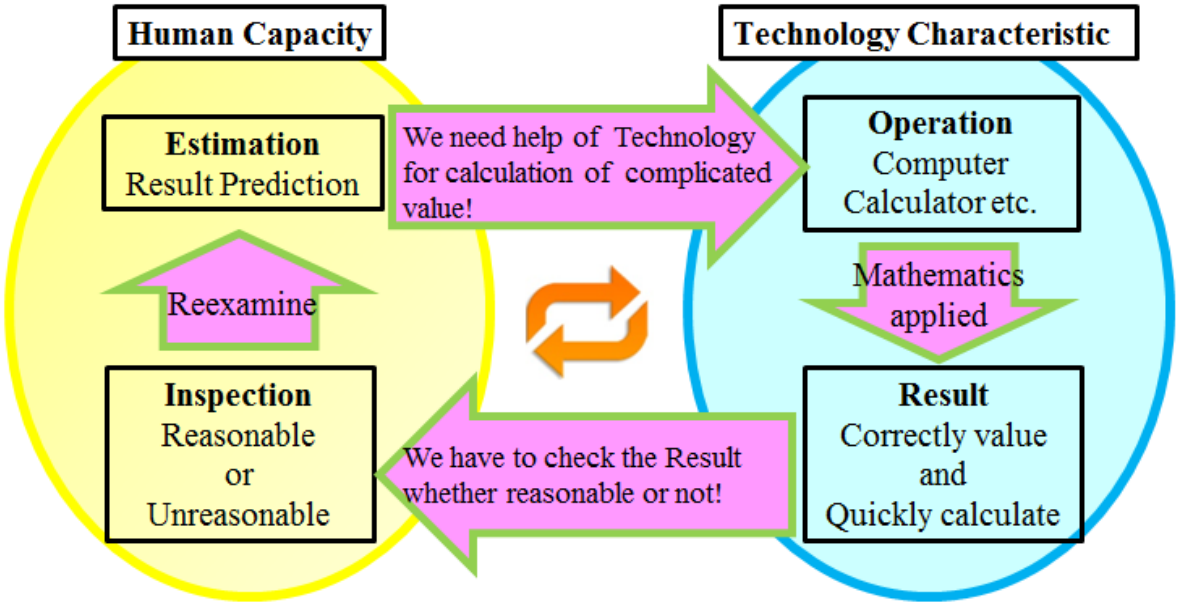

Figure 8. The model in a cycle to show the desirable relation between humans and technology.

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