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ARTICLE

Does Technology Make A Difference in Student Performance?
- An Impact Still Does Not Realize. -

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This paper examined the question whether technology make a difference in Japanese students performance. This question is answered neither positively nor negatively, because real implementation of technology into mathematics teaching is still not realized in Japan. Although the use of technology is already spelled out in the courses of study in each level and technology itself is also disseminated into schools and classrooms in Japan, the results of international surveys had revealed quite low use of technology in Japanese mathematics classrooms. The reasons of and obstacles behind the low use are examined under three pedagogical paradigms that were identified Japanese SITES project team.
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Use of Technology Is Spelled out in Japanese Curriculum

A Course of Study in Japan is a legal document and guideline what content should be covered in school curriculum and textbooks. Especially, textbooks are to be approved and authorized according to this course of study, by the ministry of education. In mathematics courses of study from elementary level to senior secondary level, the uses of technology are recommended as following:

Section 3 Planning Classroom Teaching and Dealing Contents.

(5) In the cases pupils deal with large numbers in statistics and pupils verify properties of multiplication and division of decimals, the use of calculator and Japanese abacus is encouraged after fourth grade in order to decrease pupils computational difficulties and to effective teaching. (The Course of Study of Elementary Mathematics, 1989)

Section 3 Planning Classroom Teaching and Dealing Contents.

(4) The effective use of computer should be considered if appropriate, in areas of mathematics. Especially, in the area of numbers and relations, the use of computer to observe and conduct experiment mathematics phenomena should be considered.

(5) When students deal with numerical computations, the use of calculators and Japanese abacus is encouraged, if necessary, in order to effective teaching. (The Course of study in Junior Secondary Mathematics, 1989)

In optional course Mathematics A, B and C (2 Units each), using computer and *learning computational algorithm including BASIC programming are placed in the objectives.*

Section 3 Planning Classroom Teaching and Dealing Contents in Each Course.

2 (2) In each course, the use of computer as effective teaching media will be considered, if it is appropriate.

2 (3) When students deal with numerical computations, the use of calculators and Japanese abacus is encouraged, if necessary, in order to effective teaching. (The Course of study in Senior Secondary Mathematics, 1989)

Many will expect Japanese students expose highly to technologies and utilize it in mathematics classrooms. In fact, many elementary mathematics textbooks print "calculator marks" to show the place to use it and use a photograph of computer screen to suggest computer use. Also, in the secondary mathematics textbooks, calculators and computers are printed in its' pages. As shown in the course of study, programming BASIC language for the sake of mathematics learning is included in a high school mathematics course of study, as content.

In the next course of study that just has released and is to be implemented in 2002, the use of technologies is more emphasized than recent one. Here are excerpts from next mathematics courses of study.

Section 3 Planning Classroom Teaching and Dealing Contents in Each Grade.

2 (5) In the problem solving process, after third grade, the use of calculators and Japanese abacus is encouraged when pupils deal with large numbers and complex computation. In addition to the use of these tools, estimation and verification of computation should be devised.

2 (6) The effective use of computers should be considered in order to enrich pupil's sense of number and figure and to foster pupils to present by table and graph. (The Course of Study in Elementary Mathematics, 1998)

Section 3 Planning Classroom Teaching and Dealing Contents.

4 In teaching each area, the use of Japanese abacus, calculator, computer and information communication network should be considered in order to effective teaching. Especially, the use of these tools is encouraged to observe, operate and conduct experiment numerical computation and relations. (The Course of Study in Junior Secondary Mathematics, 1998)

Using computers and learning computational algorithms including programming are place in the objects and content, especially in Fundamental Mathematics (compulsory selective), Mathematics A, B and C.

Section 3 Planning Classroom Teaching Plan and Dealing Contents in Each Grade.

2 (1) *In each course, the use of computer and information communication network will be considered, if it is appropriate. (The Course of Study in Senior Secondary Mathematics, 1999)*

The use of technologies such as, calculators, graphing calculators, and computer software, are actually emphasized in the courses of study and in textbook. Guidebooks for teachers by the ministry of education have included teaching plans of demonstration lessons that utilize technology in mathematics classrooms.

Based on the above explanation of Japanese mathematics education, one might naturally conclude Japanese students frequently expose to technologies and our high mathematics performances in international surveys such as SIMMS, TIMSS due partly to this technology use. But, unfortunately, the questionnaires on classroom teaching to teachers and student in TIMSS study had revealed a quite opposite picture of what really happened.

The Real Picture on the Use of Technology in Japanese Mathematics Classroom

Japan did not participate on the POP III survey in TIMSS, therefore a comparison between Japan and France, Netherland cannot be possible in upper secondary level. In the surveys of POP I and POP II, several questions about the use of calculator/computer are included in students' questionnaire and teachers questionnaire (National Institute for Educational Research, Monograph 126 "Mathematics and Science Achievement of Japanese Elementary and Junior Secondary Students", 1996). There are two following questions in student questionnaire: "How often do you use calculator in your math. Classroom?" and "How often do you use computer in your math. Classroom?" The result of these questions drastically contrasted with described above in regard to the use of technology.

Calculator Use

	%	Usually	Often	A few	Never
POP I	3rd Grade	0.8	9.9	0	88
	4th Grade	0.5	10.3	0	88.6
POP II	1st Grade	0.4	3.3	22.9	73.3
	2nd Grade	0.3	3.6	21.9	74.1

Computer Use

	%	Usually	Often	A few	Never
POP I	3rd Grade	1.2	10.1	0	87.5
	4th Grade	0.7	9.2	0	89.3
POP II	1st Grade	0.3	3.4	15.9	80.3
	2nd Grade	0.3	3.8	20.1	75.5

Table.1 The Actual Use of Calculator and Computer (Pupils and Students)

The tables show that calculator and computer are neither frequently used nor occasionally used. Only one tenth of elementary pupils answered they use "often" and one fifth of junior secondary students use "a few". The rest of pupils and students have never used calculator and computer in their mathematics classrooms.

What result is obtained in teacher's questionnaire? There are two questions on the use of computers: "Do you suggest students to use computer in exercises and problem solving?" and "Do you suggest students to use computer assisted drill and practice?"

Computer Use in Exercise/Problem Solving.

	%	Usually	Often	A few	Never
POP I	3rd Grade	0.0	0.7	4.9	93.8
	4th Grade	0.7	0.7	5.5	91.0
POP II	1st Grade	0.0	0.0	8.6	90.8
	2nd Grade	0.0	0.7	8.6	90.8

Computer Use in Drill and Practice.

	%	Usually	Often	A few	Never
POP I	3rd Grade	0.7	1.4	4.2	93.1
	4th Grade	0.0	0.0	2.8	95.2
POP II	1st Grade	1.3	2.0	5.9	90.8
	2nd Grade	0.0	0.7	8.6	90.8

Table 2. The Actual Uses of Computer (Teachers)

Calculator Use %		Everyday	Once or Twice in a week.	Once or Twice in a month.	A few or Never
a. Check Answers.	3rd Grade	1.4	0.0	0.7	97.2
	4th Grade	0.0	1.4	1.4	97.2
	1st Grade	0.0	0.7	0.7	98.7
	2nd Grade	0.0	0.7	2.6	94.1
b. Examination	3rd Grade	0.7	0.7	0.0	97.9
	4th Grade	0.0	0.7	0.0	99.3
	1st Grade	0.0	0.0	0.0	100.0
	2nd Grade	1.4	0.0	0.7	96.7
c. Mechanical Computation	3rd Grade	0.0	0.0	0.0	97.9
	4th Grade	0.0	0.7	1.4	97.9
	1st Grade	0.0	0.0	5.9	94.1
	2nd Grade	0.0	0.0	8.6	86.8
d. Compulex Computation	3rd Grade	0.7	0.7	0.0	97.9
	4th Grade	0.0	0.7	2.1	97.2
	1st Grade	0.7	0.0	6.6	92.8
	2nd Grade	0.0	1.3	6.6	90.1
e. Investigation of number concepts.	3rd Grade	0.7	0.0	2.1	96.5
	4th Grade	0.0	0.0	1.4	98.6
	1st Grade	0.0	0.0	5.3	94.7
	2nd Grade	1.3	1.3	7.2	88.2

Table.3 The Use of Calculator on Occasions (Teachers)

The results are almost same as found in students' questionnaire and rather disappointing than student's result. Teachers reported they did not use computers more fewer than what students reported.

The question on calculator is about "For what occasion do you ask students to use calculator?" Five occasions were listed and teacher responded to each purpose. The Upper rows show the result in elementary teachers and the lower shows the result in junior secondary level.

Another disappointing result is shown above. Teachers of elementary and junior secondary almost have never used calculator on any occasions. Even the use of calculator on complex computation is described and encouraged in the courses of study, they do not try. Only about five percents of junior secondary teachers used calculator on three occasions.

The real picture has revealed that calculator and computer are almost not used in Japanese mathematics classrooms. The situation in senior secondary school is expected to be the same as elementary and junior secondary. This fact suggests that technology in Japanese mathematics education has realized its impact neither on the way to teach mathematics, nor on students' achievement, because it is not used commonly.

Japanese national SIMSS report (National Institute for Educational Research, Monograph No.103, Mathematics Achievement of Secondary Students and Factors, 1982) had examined the correlation between students' mathematics achievement and their view toward the use of calculator and computer. The statistical relations between achievement and technology were following:

Junoir Highschool			Senior Highschool		
correlation	regression coefficient	contribution ration	correlation	regression coefficient	contribution ration
-0.112	-0.070	0.008	0.191	0.068	0.013

Table. 4 Mathematics Achievement and Calculator/Computer

These statistics were significant but quite small. The contribution ratios were only 0.008 in junior high and only 0.013 in senior high. The impact of technology on mathematics achievement in the SIMSS seemed to be very low, and it is expected to be same, today.

In fact, no drastic increase or decrease of students' achievement form SIMMS result to TIMSS result has been reported. Also, the recent national survey for curriculum revision conducted by the Ministry of Education (National Survey on Curriculum Implementation and Achievement, 1998) reported that Japanese students shown good performance in general, as they had shown the same achievement in the previous one. This survey had taken 15,000 students each from elementary and junior secondary levels, therefore a degree of confidence seems to be very high. This survey also reported that Japanese students shown good performance in knowledge and skills, and shown relatively unsatisfying performance in thinking and presentation.

Based on the document above, the impact of technology on intended mathematics curriculum is clearly shown in the courses of study. Technology has incorporated into mathematics curriculum and shows its importance on mathematics education. On the other hand, the statistical facts have shown the impact of technology on mathematics classroom is quite small and limited. Unfortunately, it seems that we cannot observe the use of technology in usual mathematics classroom. The answer to the question “Does technology make a difference in students performance” will be “No, it does not”. The possible positive answer to this question might be “The impact still does not realize.”

But this result does not due to a situation that Japanese schools are not equipped with computers and calculators. According to the statistics by the Ministry of Education (1997), 90.7% of elementary schools, 99.8% of junior secondary schools and 100% of senior secondary schools have computers. The ratios of students vs. computer are 43.2 in elementary schools, 16.1 in junior secondary schools and 11.4 in senior secondary schools. Educational software is provided through governmental organizations, public organizations and commercial software houses. The government also plans to provide Internet access to all schools by 2003. The ministry of education runs some innovative Internet school projects.

The purchase of calculators and graphic calculators are also encouraged and assisted by the Ministry of Education. Financial assistance for schools is provided through the tax return to local governments from central government. Schools can buy calculators and graphing calculators by this funding. In fact, a Japanese calculator manufacturer accomplished good business in elementary level. Graphing calculators still wait teachers’ attention to be in their mathematics classrooms.

Therefore, computers and calculators themselves are ready to be used in mathematics classroom, if teachers and students want to use. Unfortunately, the reality of the use of technology in mathematics classroom of Japan is not ready for launching it on teaching mathematics. There might be the obstacle beside hardware or the reason why technology is not used.

Why Is Technology Not Used in Japanese Mathematics Classrooms? — The Need for Good Pedagogical Orientations —

In this section, I would like to discuss the reasons why technology is not used in Japanese mathematics classrooms. Second International Technology in Education Survey (SITES) is now being conducted by IEA. SITES project now focuses on Module I the survey on schools and a collection of innovative practices. Japanese SITES task force team collected and analyzed computer-use practices from 250 schools each from elementary, junior secondary and senior secondary levels. The team concluded to categorized into followings:

1) The Practices under Traditionally Important Pedagogical Paradigm.
2) The Practices under Emerging Pedagogical Paradigm.
3) The Practices under Computer Literacy Pedagogical Paradigm.

The first category refers to the practice that technology is used for effective teaching, enrichment of traditionally important educational goals such as acquisition of knowledge, skills etc. The practices such as Computer Assisted Instruction, Demonstration by computer are included in this category. The second category refers to the practice that technology is used to realize new educational goals such as interdisciplinary studies, process-oriented learning, and constructivist learning. The practices like interdisciplinary study, cross-curricular study, research like activity are included in this category. The third category refers to the practice that technology itself or computer literacy is an educational goal. From keyboard skills, hardware knowledge, programming to HTML homepage construction, Internet access, e-mail, this category include a variety of practices.

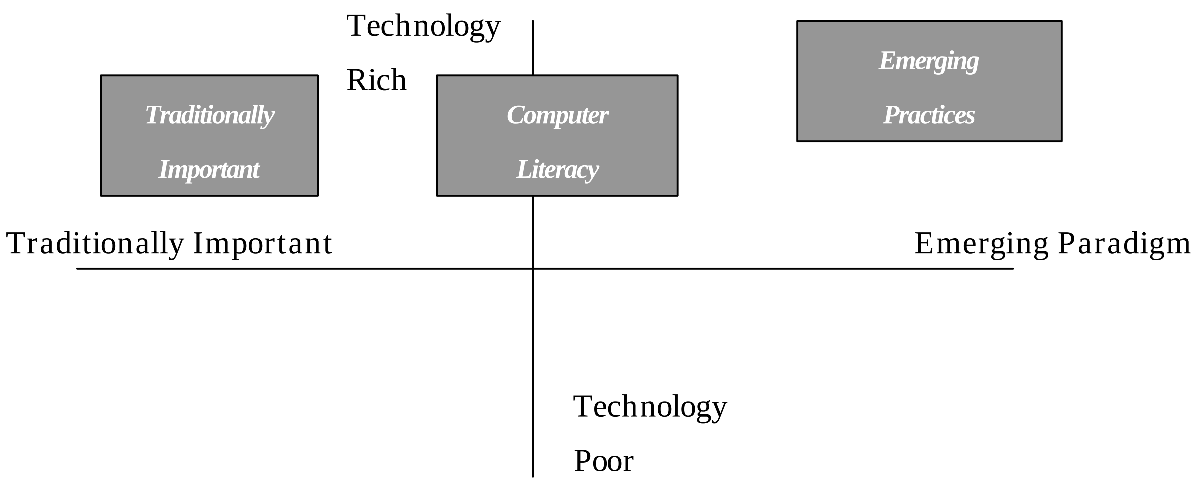

Fig.1 The Place of Three Pedagogical Paradigms in Technology-Teaching Paradigm Coordinates

These categories could be applied also to computer-use practices in mathematics education. Computer demonstration, the use of calculator, graphing calculator and symbolic software to substitute student ability of mathematical processing seem to be included in the first category. Problem solving, investigation, experimental approach, inquiry, cross-curricular activities (science and math., social studies and math. etc.,.) are to be included in the second category. Programming for mastering programming, computer algorithms, mastering how to use mathematical software are included in the third category.

Mathematics teachers and students in Japan tend to suppose the use of technology in the first category, when they encountered with it. Therefore a fear of a negative effect on student performance will occur, because students can get rid of what they suppose to master. There seems to be several pitfalls to reach this conclusion. Teachers and student may have a belief that technology is the tool for substituting human ability and is not the tool for enhancing human ability. If they have such belief, they suppose to use technology when they should not use. On the other hand, mathematics teachers who are well experienced in using technology tend to use it for seeing and observing mathematical phenomena to understand. These teachers do not see technology as substitutions.

In addition, it should be examined, for the education in the information society, whether mathematical knowledge and skills/procedure are the most important things to master or not. We should consider this question, first. And, technology does not interfere learning of such basics, if it is properly used. This fact should be taken into account, when teachers and students have a doubt on the use of technology. But this fear is very natural, because *these basics are tested* in international, national and local surveys.

The practices under emerging pedagogical paradigm also are developed in Japanese mathematics education community. Teacher Teaching with Technology group (Now, there is T3 Japan), International Group for Cabri Geometry (There have been Japanese Cabri-Geometry for ten years), Excel User Group etc., enthusiastically have developed many innovative practices. We share developed practices through Internet and mail group (mathedu mail group exists). Many books on the use of calculators/graphing calculators and its classroom practices have been published. Unfortunately, these innovative practices do not depart from our small community into the general audience of Japanese mathematics teachers. The reason why these practice keep staying inside the community seems to be following: the ability or outcome from these practices is difficult to be assessed and *this ability or outcome is not tested in surveys and entrance examinations.* Therefore many mathematics teachers and students hesitate to walk in the arena of this interesting emerging pedagogical paradigm. Actually, an effect of using technology in mathematics classroom will not directly lead the improvement of students' achievement, because the test and survey items focus mainly on what technology can do. Also the real effect of using technology is to provide students opportunities to explore mathematics be themselves and therefore to understand ideas and structures behind mathematics concepts and procedures.

The practices under computer literacy paradigm are also observed in some mathematics classroom and computer classrooms. Especially, the introduction of comprehensive study hours (three hours per week in each level) in the next curriculum implemented in 2002 will enhance an opportunity of this kind of practice. But a doubt exists also on this paradigm. Many mathematician and teachers think mathematics and informatics/computer literacy are different and should not be taught/learned at the same time. This conception on the relation between mathematics and informatics/computer literacy is the most serious obstacle, when teachers think of introducing the practice under this pedagogical paradigm. Mathematics and Informatics (the science of computers) seem to have overlapping content among them. Many mathematicians and computer scientist would agree this overlap. On the other hand, when the issue goes into the education of mathematics and informatics, educators of mathematics and informatics, especially mathematics educators, try to differentiate the education of mathematics and the education of informatics. This tendency seems to prevent an introduction of third paradigm into mathematics classrooms.

Conclusion

As described just above, there is an obstacle existing in each paradigm for its implementation. The reasons have been identified in this paper mainly concerned belief and conception of the use of technology and its prospective merits. Misunderstanding and lack of understanding in belief and conception in mathematics education might be the major obstacles for introducing use of technology into Japanese mathematics education. This will be the same in mathematics education of other countries. The course of study, hardware equipment and good software cannot overcome this difficulty. Only good models of mathematics teaching with technology will be the powerful tool to change this situation.

The question "Does Technology Make a Difference in Students Performance?" should be answered not only from superficial achievement change, but also from these pedagogical paradigms beneath the sea. When we can deal with these obstacles against the paradigms properly, and answer this question appropriately, the real and positive impact will realize, when we have provided good teaching models.

Note: This paper is based on the paper and presentation at the Panel discussion on “Does Technology Make A Difference in Student Performance Internationally” in 77th Annual Conference of National Council of Teachers of Mathematics at San Francisco 1999. The organizer was Prof. Bert Waits, and the other panelists were Collette Laborde and Paul Drijvers.