

The Japanese Word "GIJUTSU": Should it mean "Skills" or "Technology"?

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Abstract

This article examines technology education in the past two decades in Japan by focusing on lower secondary schools level. The keyword of the changes in technology education in Japan is "Information Technology." However, some people in Japan think that "Information Technology" is not adequate to teach in technology education. I will discuss what "technology" is and whether it means the same as the Japanese word "GIJUTSU" representing the subject name of technology education. Finally, I will propose the key concept for changing technology education in the future.

1. Introduction

This article examines technology education in the past two decades in Japan.

My major fields of research are not technology education but educational technology and informatics education. However, I have worked on projects related to technology education; for example, I have been engaged in research on teacher education in mathematics and science for over 20 years at the Tokyo Institute of Technology, and I have studied science and technology education with teachers at the technical high school attached to our Institute. I participated as a curriculum specialist in the workgroups of the latest Course of Study revision conducted by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and was involved in the establishment of "Information Study" as a new subject area for high school students, as well as in the revision of the "Industrial Arts" course for lower secondary school students.

This article is concerned with information technology. This was the most important issue in the recent revision of the technology education curriculum, and of teacher education. The purpose of reviewing and discussing the changes of the recent past is to elucidate what reforms will be needed for the future. In so doing it is appropriate to give attention to the technology that has effected such changes in society, and to focus on teachers, who will be responsible for future educational change.

2. Changes in Technology education in the Japanese National Curriculum

The national Course of Study has been revised twice in the last two decades, in 1989 and 1998. As a result of these revisions, technology education in Japanese schools has changed as follows:

In the first revision, it was changed from a system in which boys studied “Industrial Arts” mainly and girls “Homemaking” mainly, separately, to one in which boys and girls study the same syllabus in both “Industrial Arts” and “Homemaking”, together in one classroom. This changed the role of technology education in lower secondary schools from vocational education to literacy education in technology. Further, two subjects were now taught in the same amount of time as one under the previous curriculum, so that the amount of time given to technology education was halved. As a result, of the traditional categories within “Industrial Arts”, such as “woodwork”, “metalwork”, “electricity”, “machining”, and “cultivation”, only “woodwork” was now offered to seventh graders and “electricity” to eighth graders, whereas in the previous curriculum boys had taken four of the categories, while the remainder and “information technology”, which was newly added at that time, became optional in the ninth grade. In addition, some aspects of technology education were included in a new subject “Home Life Techniques”, established as the subject areas of “Home Economics”, which now became compulsory for boys in upper secondary schools, whereas “Industrial Arts” had been the only subject area which included technology education in elementary and secondary schools before the revision. Few schools, however, chose the new subject, because few teachers could teach it, and there were three alternatives which could be chosen from “Home Economics”.

Table 1: Changes in hours of schooling for each subject area in the three most recent versions of curriculum

	1977			1989			1998		
	7th grade	8th grade	9th grade	7th grade	8th grade	9th grade	7th grade	8th grade	9th grade
Japanese Language	175	140	140	175	140	140	140	105	105
Social Studies	140	140	105	140	140	70-105	105	105	85
Mathematics	105	140	140	105	140	140	105	105	105
Science	105	105	140	105	105	105-140	105	105	80
Music	70	70	35	70	35-70	35	45	35	35
Fine Arts	70	70	35	70	35-70	35	45	35	35
Health and Physical Education	105	105	105	105	105	105-140	90	90	90
Industrial Arts and Home Economics	70	70	105	70	70	70-105	70	70	35
Foreign Language	-	-	-	-	-	-	105	105	105
Moral Education	35	35	35	35	35	35	35	35	35
Special Activities	70	70	70	35-70	35-70	35-70	35	35	35
Optional Subjects (hours for Foreign Language)	105 (105)	105 (105)	140 (105)	105-140 (105-140)	105-210 (105-140)	140-280 (105-140)	0-30	50-85	105-165
Period for Integrated Study	-	-	-	-	-	-	70-100	70-105	70-130
Total	1050	1050	1050	1050	1050	1050	980	980	980

* One school “hour” is normally fifty minutes.

** “Foreign Language” was included in “Optional Subjects” in the curricula of both 1978 and 1989. School hours assigned to “Foreign Language” are shown in brackets.

*** In the curriculum of 1998, students must take more than one optional subject in the eighth grade and more than two in the ninth grade.

In the second revision, in 1998, teaching hours in every subject area decreased, as is shown in Table 1, as a result of Saturday becoming a school holiday. For “Industrial Arts” and “Homemaking”, the total number of school hours was reduced from 210 hours to 175 hours. Moreover, “Industrial Arts” was reorganized to

consist of two categories: “Manufacturing (Monozukuri in Japanese)”, which corresponded to the five traditional categories of “Industrial Arts”, and “Information Technology”, which was a new category added from the former revision. At the same time, “Information Technology” became compulsory, emphasizing its importance in modern society. Thus the advent of information technology has been central to the changes in “Industrial Arts” of these two decades. Some consider that “Information Technology” is not appropriately included in “Industrial Arts”. However, if it is accepted as an element in technology education, the revision of 1998 becomes epoch-making in the history not only of technology education, but of school education itself in Japan, in that “Information Study” is the only new compulsory subject area at upper secondary level to be added to the Course of Study introduced in Japan after World War II. This reform was also responsible for creating the transition from “Industrial Arts” in lower secondary to “Information Study” in upper secondary schools.

Technology education in Japan occurs as vocational and professional education, as well as in general education, and is taught in the subject area of “Industry / Manufacturing.” If we interpret the word “technology” broadly, technology education should also include “Agriculture”, “Marine Products Industry” and so on. However, I will not address changes in these subject areas in detail in this article.

3. Trends in Technology education as revealed by Japanese Textbooks

In the previous chapter, the changes in technology education in Japan over the last two decades were reviewed in terms of the revisions in the Course of Study. In this chapter, I will examine the changes in actual lesson contents through an analysis of the contents of textbooks. In Japan, each textbook company produces a textbook which must be authorized by the MEXT, after checking to ensure that it satisfies the guidelines of the Course of Study, for use in schools. Supplementary teaching materials on the market, which are not officially approved, are also often used in teaching. The analysis of textbooks is useful for inferring changes in the aims, contents, activities, and style of typical and ideal school lessons, though they are different from real lessons as I will describe in the section 4.

In Japan, only two “Industrial Arts and Home Economics” textbooks are published, by different textbook companies, and each company has almost similar share of the market.

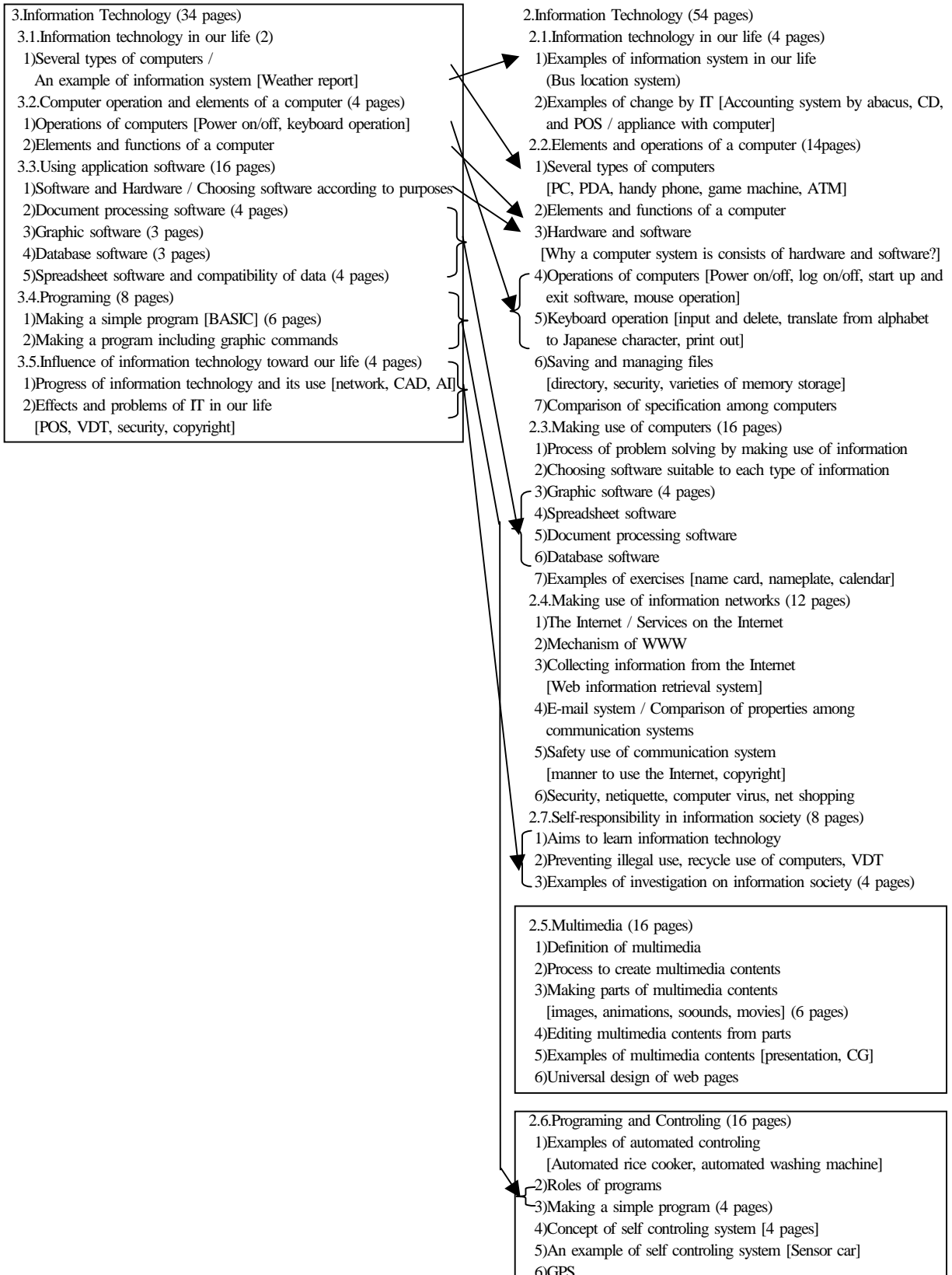
Because textbooks are not revised for at least four years, there are only four editions of the textbooks used during the previous and the present Course of Study. Of those four, I chose two from the same publisher for the present analysis. One was published in 1993, the first edition based on the revised Course of Study announced in 1989, and the other will be published in 2006 as the second edition based on the revision of 1998. Textbooks of the 1980s were not obtainable, but their contents can be readily inferred from a tendency to be described below. As mentioned in section 2, only the structure of the course, and not the contents, was revised in 1989.

Table 2 outlines the two textbooks. For the 1993 edition, the syllabus for “Information Technology”, which was then a newly established optional area, is given, in addition to those for “woodwork” and “electricity”,

in the compulsory area. It has become compulsory in the 2006 edition. For the 2006 edition,
Table 2(a). Contents of Textbooks: 1993 edition (left-hand side) and 2006 edition (right-hand side)

<p>1. Woodwork (50 pages)</p> <p>1.1. Woods and our life (2 pages)</p> <p>1) Woods in our houses / Uses of woods [fuel, chemical products, wood products]</p> <p>1.2. Features of woods (12 pages)</p> <p>1) Cutting and examining woods</p> <p>2) Making a simple wood product / Summarizing features of woods [comparing with metals and plastics]</p> <p>3) Kinds of woods and tissue of woods</p> <p>4) Properties of woods [deformation, properties to heat and sound, strength]</p> <p>5) Examples of wood products</p> <p>6) Houses and woody musical instruments / Kinds of wood materials</p> <p>1.3. Designing wood products (10 pages)</p> <p>1) Planning / Flow of woodworking</p> <p>2) Considering functions [shape, size, usability], structure, and materials</p> <p>3) Choosing production methods / Varieties of methods to joint wood parts</p> <p>4) Summarizing a plan / Preparing to work [Making a parts table and a process chart]</p> <p>5) Examples of product concept</p> <p>1.4. Technical drawings (8 pages)</p> <p>1) Cabinet projection drawing / isometric drawing</p> <p>2) Orthographic projection drawing</p> <p>3) Kinds of dimension line / Writing Size</p> <p>4) Process of technical drawing</p> <p>1.5. Making woodwork products (16 pages)</p> <p>1) Scribing</p> <p>2) Sawing</p> <p>3) Auto sawing machine and auto planing machine</p> <p>4) Planing (4 pages)</p> <p>5) Work process of tenon and mortise</p> <p>6) Jointing wood parts and painting (4 pages)</p> <p>1.6. Efficient use of woods (2 pages)</p> <p>2. Electricity (38 pages)</p> <p>2.1. Electricity in our life (2 pages)</p> <p>1) What will be happened by blackout? / Process of electric power supply and consumption / Uses of electric power [light, heat, kinetic power, electronic signal]</p> <p>2.2. Electric circuit (12 pages)</p> <p>1) Electric circuits and their schematics</p> <p>2) Making a simple circuit tester and an extension cable / Summarizing properties of electricity</p> <p>3) Usage of a circuit tester (4 pages)</p> <p>4) Power sources and loads [DC and AC, Ohm's law, Power] / Switches</p> <p>5) Electric cords / Cord assembly</p> <p>2.3. Mechanism of electric appliances and method of maintenance them (10 pages)</p> <p>1) Mechanism of electric appliances [Iron, Desk stand, Washing machine, Radio]</p> <p>2) Test of electric appliances / materials [conductor, resistor, insulator, semi-conductor]</p> <p>3) Examples of electric appliances [kotatsu, light, wind fun, radio] (6 pages)</p> <p>2.4. Electric appliances and in-door wiring (4 pages)</p> <p>1) Power board / preventing electric shock</p> <p>2) Rating of electric cords and parts / Safty use of electric appliances</p> <p>2.5. Design and assembly of an electric circuit (8 pages)</p> <p>1) Functions and usage of electronics parts</p> <p>2) Amplifier effects of a transistor / Process of circuit design</p> <p>3) Examples of electronic circuits and their assembly (4 pages)</p> <p>2.6. Efficient use of electric power and progress of electric engineering technology (2 pages)</p>	<p>1. Technology and "Monodukuri" (86 pages)</p> <p>1.1. Technology and our life (6 pages)</p> <p>1) Influence of technology advancement on our life [rice cooking, washing, preserving foods, communication]</p> <p>2) Technology advancement in the use of energy</p> <p>3) Enjoying "Monodukuri" [Examples of products for practicing]</p> <p>1.2. Design of Products (20 pages)</p> <p>1) Outline of "Monodukuri" [from design to production]</p> <p>2) Investigation of products in our life and tools in an assembly room</p> <p>3) Planning (method for collecting, creating, and evaluating ideas)</p> <p>4) Choosing materials (properties suitable for purposes and functions)</p> <p>5) Features of woods, metals, plastics, and so on. (6 pages)</p> <p>6) Making products stronger and improving usability [Consider shape, size, structure, and functions]</p> <p>7) Investigating and choosing production methods [Examples of jointing and bending methods]</p> <p>8) Summarizing and drawing a plan</p> <p>1.3. Technical drawings (10 pages)</p> <p>1) Cabinet projection drawing / isometric drawing / writing size</p> <p>2) CAD / Orthographic projection drawing</p> <p>3) Examples of product concept (6 pages)</p> <p>1.4. Making products (26 pages)</p> <p>1) Outline of producing</p> <p>2) Preparing to work [Making a parts table and a process chart]</p> <p>3) Scribing</p> <p>4) Sawing and cutting (4 pages)</p> <p>5) [planing / filing and making holes / bending and twisting off / checking, making tenon and mortise, lathe turning] process of parts (8 pages)</p> <p>6) Assembly of parts (4 pages)</p> <p>7) Painting</p> <p>8) Casting of plastics and metals/ Maintenance for using longterm</p> <p>1.5. Mechanism of machines and tools and methods to maintain them (16 pages)</p> <p>1) Scenes of maintenance works [airplane, car, escalator, bus, and bicycle]</p> <p>2) Investigation of [common] parts in machines and tools</p> <p>3) Investigation of mechanism for conveying kinetic power [rotation]</p> <p>4) Investigation of mechanism for using electricity [DC and AC, Ohm's law, Power]</p> <p>5) Electric circuits and their schematics / Circuit tester</p> <p>6) Accident prevention [leak current, Rating]</p> <p>7) Check Methods for safety use of machines and tools</p> <p>8) Safety use of electric appliances / Assembling a table tap</p> <p>1.8. Direction of technology progress (8 pages)</p> <p>1) Technology and ecology [recycle, efficient use of energy, technology for ecology]</p> <p>2) Examples of recycle use/ecological use of technology in our life</p> <p>3) Examples of study on technology in our life [ecology and technology / technology for welfare and universal design]</p> <p>1.6. Transformation and making use of energy (22 pages)</p> <p>1) Process of electric power supply and consumption</p> <p>2) Transformation and making use of electric energy (4 pages)</p> <p>3) Functions and use of semi-conductor parts</p> <p>4) Mechanisms for conveying motions [gear, cam, link, belt, chain] (4 pages)</p> <p>5) Making a product which applies energy transformation</p> <p>6) Examples of product [Several types of lights, machine model] (4 pages)</p> <p>7) Let's take part in a robot contest</p> <p>8) Methods to save energy in our life</p> <p>1.7. Cultivation (20 pages)</p>	
<p>4. Metalwork</p>	<p>5. Machining</p>	<p>6. Cultural</p>

Table 2(b). Contents of Textbooks: 1993 edition (left-hand side) and 2006 edition (right-hand side)



* Each item is corresponding to two pages unless there is no description about numbers of pages

* means optional.

for all syllabuses (except “cultivation”) a distinction between compulsory and optional is shown, to make clear which had become optional by 2006. “Cultivation” is shown for neither edition because it was always optional and the election rate was quite low.

3.1 Trends in the Traditional Contents of “Industrial Arts” – “Monodukuri”

The first trend observable in Table 2 is that the categories of Industrial Arts in the 2006 edition are integrated while each category in the 1993 edition is kept separate. This difference reflects a loss of categories due to the reduction in teaching hours and the introduction of “Information Technology” as a compulsory subject. There was the further change in objective to studying the “Industrial Arts” from the point of view of their usefulness in real life rather than just the technical skills. Figure 1 shows the ancestry of “Industrial Arts”. In its inception it was influenced by “Arts and Craftwork” and “Vocation”, and its main contents in the 1993 edition was the acquisition of the fundamental knowledge and skills needed to become, for example, carpenters and furniture upholsterers in “woodwork”, or electrical engineers in “electricity”. By contrast, in the 2006 edition, the concentration is on design, and instruction in “woodwork” and “metalwork” is combined (sections 1.2, 1.3, and 1.4). Metals and plastics, in addition to wood, are now included in the materials used to make products. Since many household goods are made from metals and plastics, learning about those materials will allow students to make things out of materials to hand and to repair household goods. Similarly, the design of a circuit and making electrical products in “electricity” in the 1993 text become optional in the 2006 version (section 1.6), while using electricity safely and efficiently and how to repair electrical appliances are compulsory (section 1.5). These changes suggest a focus on the knowledge and skills necessary for ordinary persons to cope with the products of technology in everyday life.

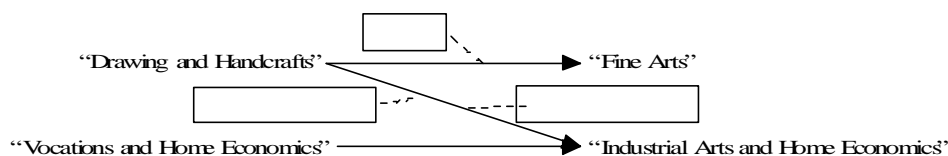


Figure 1: Ancestry of “Industrial Arts” from the Course of Study of 1958

Similarly, in the 2006 edition, the sections “1.1 Technology and life” and “1.8 Directions in future technology”, which relate technology to changes in daily life and society, emphasize the viewpoint of the user rather than the developer or maker. Superficially, these contents might appear similar to sections 1.1, 1.6, 2.1, and 2.6 of the 1993 edition. In reality, their main concern is with the effect of technological progress on users’ needs and lifestyle, to which is added a moral emphasis on the necessity, beyond individual convenience, of choosing desirable technology from the point of view of saving resources and the environment. A further change in the 2006 edition is a trend to problem-solving activities, and there is more concern with ways of thinking and collecting information to support such activities.

Only section 1.5 of the 2006 edition is against the trend to emphasize the needs of users, and deals with machines and tools for production. While section 2.3 of the 1993 edition mainly deals with home electrical

appliances, this topic becomes optional in section 1.6 of the 2006 edition.

The 1998 revision of the Course of Study sought to reduce the repetition of material in different subject areas. For example, the basics of electricity are now taught at the end of the seventh grade, and “motion and energy” in the second half of the eighth grade, in “Science”, before being encountered in “Industrial Arts”, but were taught after “Industrial Arts” in the 1989 version of the Course of Study.

3.2 The Trend in “Information Technology”

In the 1998’s revision of Course of Study, “Information Technology” became compulsory. Its contents increased especially in “2.2 Elements and operations of a computer” and “2.4 Making use of information networks”, and material on the influence and role of information technology in our society increased moderately. The reason for the increase in section 2.4 is related to the spread of computers in the home. In Japan, because of the need for thousands of Japanese characters, it takes time to master the entry of data to a computer. This has been a barrier to ordinary persons learning to enter and process information by themselves.

However, computers became more familiar and acquired more use at home after various services had been provided on the Internet making it easier to exchange data, aided by the reduction of fees due to the opening up of the telecommunications market. Now, cellular phones are in widespread use as telecommunication terminals. Many lower secondary school students have access, and this exposes them to various risks from information networks. There is also concern about security and file management because of increased use of networks and multi-user operating systems. Furthermore, it is considered desirable that people have the skills to choose the best solution among various alternatives for a given purpose and situation, emphasizing the flexibility of computers as a problem-solving tool.

Nevertheless, in “2.3 Making use of computers” in the 2006 edition, the kinds of software explained are almost identical with those in “3.3 Using software applications” in the 1993 edition. However, while in the 1993 edition each software package was treated independently, in the 2006 edition, the emphasis is on methods and ways of solving problems, such as decomposing and identifying the information necessary for a target product or solution, employing suitable software, and unifying or reconstructing the output. A significant change is that programming using the language BASIC, which was given emphasis in the 1997 editions, has become optional in the 2006 editions. To summarize, as in the case of “Industrial Arts”, change is directed at the needs of users rather than developers in the later syllabus of “Information Technology”.

3.3 The Influence of Increasing the Ratio of Students Entering Higher Schools

Another reason which affected the change of “Industrial Arts” is the increase of the ratio of lower secondary students going on to upper secondary schools and that of upper secondary students going on to institutions of higher education. The proportion of lower secondary students entering upper secondary education in 1955 was about 50%. It increased steadily to reach 90% by 1975, and is currently over 97%. Moreover, the ratio of students in vocational high schools was about 40% in 1970, but is now less than 25%.

The proportion of students going on to institutions of higher education had reached about 50% by 1978. There followed a ten year period in which the percentage did not change, but an increase began again in about 1987, and the rate has now reached about 73% (MEXT 2004). This trend means that the point at which students decide on their future occupations comes later. If technology education focuses on vocational education at lower secondary school level, it then becomes difficult to motivate students' interest in technology. Under the present Course of Study, career education in lower secondary schools was introduced in "Periods for Integrated Study", and provides students with the chance to investigate occupations, experience the workplace, and so on.

4. "Gijutsu" in Japanese: Is It the Same as "Technology"?

If Japanese people are asked which subject areas come under technology education, a variety of answers will be received. These differences originate essentially in differences in the understanding of the term "technology", for which the Japanese word is "GIJUTSU".

A review of some recent versions of the Course of Study shows the word "GIJUTSU" used in the sense of "skills" or "techniques". For example, among the objectives of "Industrial Arts" was "to give students mastery of GIJUTSU (= skills) required in daily life and foster creativities and practical attitudes to enrich their lives". Technology education in this sense was already provided in "Drawing and Handcrafts" in both elementary and lower secondary schools, before "Industrial Arts" was established in the latter as described above.

Nevertheless, when the Course of Study was revised in 1989, a new objective, "to give an understanding of the relationship between life and GIJUTSU (= technology) in the home and society" was added, implying the introduction of new aspects of technology education. The use of the word GIJUTSU (= technology) here stresses its objective and intellectual aspects, its concepts, ideas, and methods of designing artifacts and systems; that is to say, it emphasizes the engineering mind. "Technology" in this sense was also introduced into "Science" in the 1989 revision with the inclusion of the phrase "to understand the relationship between the progress of science and technology and changes in our way of life."

The reason why "GIJUTSU (=technology)" has been understood to mean skills can be found in its origin as a Japanese word. The English word "technology" is composed of the Greek "techno (= art)" and "logos (=knowledge)". Therefore, it connotes the discipline of the arts (in the broadest sense). The Japanese word "GIJUTSU" is composed of "GI (=WAZA)" and "JUTSU", and both "WAZA" and "JUTSU" have the meaning of art or technique in English. Therefore, "GIJUTSU" education simply means training in skills. In Japan, the word "KOUGAKU" is the word for the discipline of the arts. However, since the meaning of the word "KOU" is "processing", "KOUGAKU" corresponds more closely to the English word "engineering". Thus, Japanese people gave it the connotation of manufacturing technology, whereas in fact "technology" is a larger concept than "engineering", as is clear from the existence of the term "engineering

technology” in English.

The meaning people give to the word “technology” is likely to be influenced by what is taught as “technology” in technology education, and how technology education teachers understand the meaning of “technology” and convey it to students is probably also very influential. As described above, the meaning of “GIJUTSU” in the Course of Study and its textbooks has changed over time from skills to technology. However, it is not clear that teachers are aware of the nature of this change, because lessons of “Industrial Arts” we can see in many schools are different from the ideal one described in section 3. The stereotypical form of real lessons is that parents purchase work kits, students assemble them and bring the artifacts home, in return for the money, just to throw them away as garbage because they are not useful in many cases.

In considering the future of technology education in Japan, we must reflect on the meaning of the word “GIJUTSU (= technology)” and interpret it to students. Further, whether we emphasize technological skills or intellectual understanding as the goal of technology education is bound to be a source of controversy. It should also be decided whether we wish to teach practical skills that are accessible to most people, or rather, concentrate on imbuing attitudes and behaviors to reflect their opinions on how to use technology in our society through the democratic process. Parents and teachers, including university professors, should take such questions seriously, and ensure that children, who will one day be parents, understand the meaning they are giving to technology. However, many teachers think that controversy is dangerous to their status, and avoid confronting such issues.

The present status of technology education in Japan demonstrates the harmful effect of renegeing on such discussions. In the Course of Study, subjects are classified as either “main” or “other” subjects. The main subjects are “Japanese”, “Social Studies”, “Mathematics”, “Science”, and “English”, while “Industrial Arts” is in the category of “other subjects”. Most students recognize the main subjects as important because they must pass the entrance examinations in these subjects to go on to higher education; whereas they consider the school hours devoted to other subjects as a time to relax and enjoy school life. In some private schools, extra school hours are assigned to the main subjects by cutting down the hours of the other subjects, because of parental ambitions to enter their children in one of the famous universities.

However, this approach is not necessarily successful in creating a regard for these subjects. According to a survey by the National Institute for Educational Policy Research (NIER 2003), the rates for seventh graders, who agreed to “I like learning mathematics” and “I understand lessons in mathematics”, were approximately 45% and 50%, respectively, and the rates for the same questions for “science” were 55% and 50%. Moreover, according to the NIER survey in 2004, the rates for twelfth graders, who agreed to “it is important to learn mathematics even if it is not required in entrance examinations,” “it is useful to learn mathematics for use in daily and social life”, and “I want a job in which I will use mathematics”, were 40%, 33%, and 12%, and the rates for the same questions for “science” were 30%, 30%, and 18%. Thus, the strategy of using examinations as a motivator for studying means that students fail to appreciate the subjects themselves. This outcome was pointed out in “White papers on science and technology” as long ago as 1993. It was shown that the level of interest of persons in their twenties in science and technology topics and news was markedly lower than that for other age groups. Further, as the number of children of

school age decreases, competition in entrance examinations is no longer a strong source of motivation for students. Therefore I suggest that subjects should be classified as main or other subjects depending on whether they are useful for the solving of problems in the real world. I am convinced that technology education should be a main subject in that it promotes understanding of the tremendous influence technology has on our society.

5. Technology education in the Future:

Learning from Discussions of Teaching Information Technology

Fortunately, there was no choice but to discuss why the study of information technology is needed when the question of the new subject area of "Information Study" was raised. The justification for the establishment of "Information Study" was finally agreed to be, to provide students with the following abilities in the utilization of information for practical problem solving in daily life and society.

1. The practical ability to make use of information in problem solving and communication, with the knowledge to decide when or not to use information technology, without being misled by its seeming usefulness.
2. Understanding the appropriateness of methods for making use of information and information technology adequately, based on their properties.
3. Developing attitudes sympathetic to taking part in the creation of a desirable information society with an understanding of the roles of information and information technology and their influences on our society.

It is notable that the operational skills for computer use were not included in these objectives. Of course, this does not imply that learning to operate computers is unnecessary, but rather stresses that the focus of the teaching is not on mastering the skills involved in operating computers, but on understanding the respective roles of technology and human beings, and what should be learned about technology.

Based on the argument so far, I insist that we should cope with the following two issues so that the "GIJUTSU" education of Japan, which emphasizes acquisition of skills, would change into technology education as it originally means.

Firstly, we have to change the system and curriculum of teacher education. As I have already stated in this article, even though the National Course of Studies and textbooks are revised, if teachers' consciousness keeps as it has been, the technology education in schools remains almost unchanged. In Japan, it is said that the number of retiring teachers will increase and many teachers will be newly employed during about ten years from now on. Moreover, the council of the MECSST has been working on how to improve teachers' qualities. Thus, we should not miss this chance to reform the system of both teachers' license and teacher training in technology education.

Secondly, we should have an innovative idea which would be recognized the core of technology education reform. The idea must be a basic concept that unifies "Monozukuri" and "Information Technology." Hereafter, I will describe my idea created in the process of making the informatics education curriculum.

The curriculum for “Information Study” was never a single person's conception, but the philosophical basis of my views comes from two papers, “Study of the Information Industry” and “Civilization from Information Technology”, by Tadao Umesao, a Japanese cultural anthropologist. The former, written in 1963, argued that we should see the mass media, movie productions, schools, and religious parties as information industries, if we define the word “information” as “all the sign series transmitted between human beings.” To this he later added a supplement extending the meaning of information as follows: “Information is not necessarily sent by anyone. Everything in the world is information just as it is. It is a matter for each individual as to whether he/she can invoke it as information or not.” He claimed that most of the industries that trade by adding attraction to the basic products themselves, such as travel agencies, leisure industries, restaurants, fashion brands etc., should be regarded as information industries. In the second article, written in 1988, he discussed the idea that changes in civilization result from the advancement of information technology. The point of his discussion was that information technologies should be seen as tools for managing information, and information is central to the understanding of our thoughts, behaviors, and many aspects of society. Therefore, the main concern of “Information Study” is information itself. In order to utilize information, to make our lives richer and safer and society better, we need to learn how to use information technology appropriately.

From my experience of establishing a new subject area, we need to examine and reorganize the contents of technology education. For example, there are three aspects to our control of the material world – matter, energy, and information. It could be helpful to explain the development of technology from these three angles, and to discuss ideas on transforming materials, energy, or information more efficiently and effectively. The concept of “transformation” is an important viewpoint to understand technology systematically; in addition, it is an important power to support way-of-thinking power required in technology. In cognitive psychology, coming up with an idea bringing a deadlock to an end is called “discernment” and solving a problem creatively is called “discernment problem solving”. “Discernment” requires the change of the way of thinking, so it is necessary to transform the representation of a problem situation and work on the problem from the various viewpoints. That is, if we replace the word “technology power” with “problem-solving power”, it is important to teach how to transform the ways of thinking and represent problem situations in technology education. For example, a simulation can be interpreted as one of the ways to solve problems by changing a phenomenon in the material or the energy world to a phenomenon in the information world. The technology of remote control can be interpreted as a method to transform a phenomenon in the physical world to a phenomenon in the information world, and to transmit, process, and again transform to a phenomenon in the physical world. From this point of view, the contents of “Monodukuri”, which treats the transformation of materials or energy, and “information technology”, which treats the transformation of information, must be integrated in the future technology education although they are separated at the present moment as is shown previously.

Furthermore, the idea of “transformation” is related to ideas in mathematics and science. In order to transform and process coded data as you wanted, it is necessary to use either advanced mathematics or the combination of simple mathematics and an information technology. In order to transform materials and

energy or to transform them to information, it is necessary to use the scientific laws. For example, you could know the height of a building by measuring the length of a rope hanged down from the top as well as measuring the time or the kinetic energy of a thing fallen down from the top to the land. You could also know it by comparing the length of the shadow of a one-meter stick with that of a building. Thus, if you have scientific knowledge such that under certain conditions length can be transformed to speed, kinetic energy, time, and so on, you can easily solve the problem of measuring a phenomenon which cannot be measured directly. I think that it is possible to give children motivation toward learning mathematics and science by connecting the purpose of studying these subjects with technology (= problem solving). Therefore, we should not retain technology education within a narrow frame to conserve its uniqueness, but should try to broaden it and think that it is ideal that various subject areas are related to technology education. This is just the same as informatics education being performed in the several subject areas. This will not lower the necessity of specialists of technology education, because the discipline of science is essentially different from that of technology; that is to say, science is concerned with discovering the laws of nature and technology is concerned with creating the future. It is necessary to do science education and technology education to children either with interests in science or with interests in technology as they grow up.

References

MEXT (2004) "Japan's Education at a Glance,"

http://www.mext.go.jp/b_menu/shuppan/toukei/04042301/002.pdf (in Japanese)

MEXT (1998) "the Course of Study for Lower Secondary Schools,"

http://www.mext.go.jp/b_menu/shuppan/sonota/990301c.htm (in Japanese)

MEXT (1989) "the Course of Study for Lower Secondary Schools,"

http://www.mext.go.jp/b_menu/shuppan/sonota/890303.htm (in Japanese)

MEXT (1977) "the Course of Study for Lower Secondary Schools," MEXT, Tokyo, Japan

National Institute for Educational Policy Research (2003) "Reports on Comprehensive Evaluation of the Learning Proficiency of School Students: Primary schools and Lower Secondary Schools,"

http://www.nier.go.jp/kaihatsu/katei_h13/top.htm (in Japanese)

National Institute for Educational Policy Research (2004) "Reports on Comprehensive Evaluation of the Learning Proficiency of School Students: Upper Secondary Schools,"

http://www.nier.go.jp/kaihatsu/katei_h14/index.htm (in Japanese)

T. Umesao (1963) "Study of Information Industry," *Tyuuou-kouron*, 605, 46-58 (in Japanese)

T. Umesao (1988) "Civilization from Information Technology," *Tyuuou-kouron*, 1231, 152-172, *Tyuuou-kouron* (in Japanese)

H. Ishida, T. Chuuma, A. Abe, and S. Shibukawa [eds.] (1993) "New Industrial Arts and Homemaking," Tokyo-shoseki, Tokyo, Japan

K. Kato, K. Nagano, S. Shibukawa, and S. Watanabe [eds.] (2006) "New Industrial Arts and Homemaking," Tokyo-shoseki, Tokyo, Japan, (in press)