K12 IT Education in Japan: Current Status and Future Directions

Yasushi KUNO*[1], Ben Tsutom WADA†[2], Yasuichi NAKAYAMA‡[3], Takeo TATSUMI§[4], and Eriko UEMATSU¶[5]

[1]University of Tsukuba
[2]Nagano University
[3]University of Electro-Communications
[4]The Open University of Japan
[5]Musashino Gakuin University

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1 Introduction

Currently, many countries are starting (or planning) to enhance K12 informatics education programs. Recently, programming (or computer science) education in elementary schools is hot topics; United States' "Hour of Code" activities (around 2013) and "Computing" subject in England (starting at school year 2014) are representative ones.

Japan, our country, is not an exception; prime minister office has published "Declaration to be the World's Most Advanced IT Nation" in June 2013[5], in which "programming in compulsory education" is announced. However, Japan's informatics education suffers from many problems, and activities toward the restructuring has just started. Additionally, Japan is currently in the process of drastic reform of connection between high school and college / university, and thus our informatics education system for primary and secondary schools should be harmonized with the reform policy.

The authors are members of IPSJ (Information Processing Society of Japan) educational committee and have had much interests in Japan's K12 informatics education since 1997, when the government had published the document for introducing informatics education into schools[4].

In this paper, we try to give overview for Japan's informatics education system at present, and explain our proposals for direction to proceed from here. The rest of this paper is as in the following: In section 2, we explain current status of Japan's K12 informatics education along with many surrounding problems. In section 3, based on the analysis of documents published by MEXT (the Ministry of Education, Culture, Sports, Science and Technology), we propose a list of topics to be covered by high school informatics education along with their achievement levels. In section 4, we discuss K12 informatics education through elementary school to high school. [1] In section 5, we summarize our arguments.

*kuno@gssm.otsuka.tsukuba.ac.jp
†wadaben@acm.org
‡nakayama@uec.ac.jp
§ttmtko@gmail.com
¶eriko.uematsu@u.musa.ac.jp

[1]Although K12 includes kindergartens, currently we do not have enough material to duscusse them, so we left out them in this paper.

2 Japan's K12 Informatics Education: Current Status

2.1 Ability to Make Use of Information

In Japan, systematic informatics education has only started in 2003, when a new subject "information study" was created by the Ministry of Education (now reorganized to MEXT). Before that time, the ministry had published a report by collaborators' committee[4] that defined the goal of K12 informatics education as "ability to make use of information," with following three sub goals:

- Practical skills to make use of information — skills to collect, judge, express, process and create information in a proactive manner. Additionally, skills to consider recipients' situation in the process, and skills to choose appropriate measures (tools, devices and so on) according to problems / goals are also included.
- Scientific understandings of information — understandings of information measures' characteristics, how to handle information properly, and basic theory and measures to evaluate and improve one's information usage.
- Attitude to take part in information society in an active manner — understandings of effects and roles of information and information technology in our society, and attitude to recognize necessity of information morals and our responsibilities on society, and attitude to actively participate in creation of desirable information society.

In our opinion, these goals are well thought for the time. However, in today's standpoint, there are weak points in that (1) they do not reflect recent increase in importance of IT, and (2) relationships with higher education are not clear.

2.2 Status of High School "Information Study" Subject

The first version of high school "information study" course guidelines (announced in 1999) included three subjects "Joho-A," "Joho-B" and "Joho-C [2]." They all covered the above three goals, but emphasis were put on "practical skills," "scientific understandings" and "attitude in information society" correspondingly, and every students have to study at least one of these according to their interests.

Now we explain what have happened. First, as "information study" was all new subject, schools needed licensed teachers of it. Although many colleges / universities founded courses for the license, due to urgent needs, MEXT has held many training courses in which teachers licensed in other subjects (math, science and so on) could receive "information study" license in 15 days lecture. This special training was held in school year 2000, 2001 and 2002, and 14,269 teachers have received the license. Of course, 15 days are far from sufficient to become a competent informatics teacher; they often can only teach how to use application software.

Second, many school managers (and colleague teachers) have misunderstood that "information study" is a subject for how to use computers, and considered it as unimportant. That was unavoidable because there were so many non-competent teachers (as noted above) and they have chosen the "easiest" Joho-A textbooks which looks like how-to-use manuals. These textbooks do really have proper contents and get approved by MEXT, though they put emphasis on how-to-use and contain many manual-like screenshots. At the starting point, as much as 80% of the students have to study Joho-A, because schools gave no other choice (due to lack of resources).

Third, this "unimportant" impression has led to still more severe problems. In 2006, it

[2] "Joho" is Japanese word for information / informatics.

was revealed that many high schools has neglected to teach “information study” classes, assigning those hours to “more important” subjects. Other schools have gathered whole students to gymnasium and gave lectures by external speakers as “information study” classes. Such negligence occurred because “information study” were not included as an examination subject of National Center of University Entrance Examination of Japan (because the subject seemed unimportant). School managers were reluctant to spend money to hire “information study” teachers, so many classes are being taught by part-time teachers, and still more classes are taught by teachers of other subjects who happened to have spare hours (school managers could request the domestic board of education to give “temporary license” in an emergency; of course above cases were not in emergencies at all).

In 2008, new course guideline for “information study” has been published (actual classes started in 2013). That guideline included two subjects “Society and Information” and “Science of Information,” which are descendant of Joho-C and Joho-B respectively, and easy Joho-A was dropped. However, many teachers still teach application software usage (ignoring course guidelines). Now 80% of the students learns “Society and Information” because many teachers evade “Science of Information,” which include programming basics and elementary algorithms.

This is the current situation; a vicious spiral of non-competent teachers and misunderstanding to regard the subject as “unimportant” has been hard to break. However, several movements toward reform have appeared recently.

First, in recent investigation meeting for the coming course guidelines, whose publication is scheduled around 2018-2022, MEXT has announced that they are planning for a single mandatory subject, which is a descendant of “Information of Science” for high school “information study,” along with elective (more advanced) subject for interested students.

Second, as noted previously, a drastic reform of connection between high school and college is discussed, and MEXT is planning to include “information study” for both high school achievement level examinations and college entrance-level examinations. If those were realized, school managers could no longer regard “information study” as unimportant; neglection will decrease and more competent teachers will be employed in full-time, as we hope.

However, note that such examination reform are scheduled after installation of new course guidelines (several years after their announcement, that is, around 2024-2028). We think we should strive for more prompt improvement of current practices.

2.3 Status of Compulsory Education

We have spoken about high school status so far; informatics education from younger ages will become important, as noted earlier. With respect to this, no systematic informatics education is determined for elementary schools (six years starting at age 6); what kind of informatics education to implement is largely up to school managers, and often there are no informatics education at all.

In junior high school (three years starting at age 13), “technology and home economics” subject includes minimal hours of informatics education. Although topics on computer sensing and control (with programming) are included, they occupy rather small fraction; majority of the hours are used for how-to-use topics. Another bad news is that “technology and home economics” teachers are not prepared to teach ICT topics, and thus programming topics are often skipped.

Good news in this area is that, stimulated by the announcement form prime minister’s office[5], MEXT is now investigating how to include programming curriculum in compulsory education. However, outcomes of the investigation are not made public yet, and we know that so many things have to be improved in our compulsory education system (avoidance of bullying, English education, active learning, and many more...). We will return to compulsory informatics education topics later.

3 Proposal: New Goals of Japan's Informatics Education

3.1 Bachelor's Abilities

In December 2008, the Central Education Council of MEXT has published a report named "Toward the Construction of Bachelor Education Program[1]." The report includes many detailed discussions, among which the concept of "bachelor's abilities" is described. Bachelor's abilities are defined by a standardized list of abilities which every student to receive bachelor's degree should possess. Actually, they are categorized into following four groups:

1. Knowledge and understandings — systematic understandings of fundamental knowledge in the specific discipline which the student majors. Examples are: understandings of knowledge about different cultures in multiple cultures, understandings of knowledge about the societies, nature and / or human culture.
2. Generic skills — skills required in intellectual activities, vocational activities and social activities. Examples are: communication skills, numerical skills, information literacy, logical thinking abilities, and problem solving abilities.
3. Attitudes and intentionalities — self management abilities, team membership and leadership, ethical viewpoint, social responsibilities as a citizen, lifelong learning abilities.
4. Integrated learning experiences and creative thinking abilities — abilities to establish and solve one's own problems.

The list above describes abilities which students are expected to possess when they receive bachelor's degree. However, those abilities cannot be attained in a few years, and there also are abilities needed to acquire others (abilities for studying). Therefore, colleges need to assess their applicants with those abilities. Another related document is "reference standard in informatics[2]." Although the document is focused on informatics discipline and thus not applicable to general K12 education, it does have many discussion on generic skills (related to informatics), which we have consulted.

Below, we focus on those abilities that K12 informatics education are in charge, and discuss their extents and levels required for successful development of bachelor's abilities when students proceed to higher education. In the following subsections, we first list up elements of those abilities, based on the four groups listed above, and then reorganize those elements to groups and discuss their desirable levels (symbols are assigned according to the category after reorganization).

3.2 List of Abilities Related to Informatics Education

3.2.1 Knowledge and understandings

Knowledge and understandings are defined and evaluated based on each of the discipline which students major, so informatics education seems not to be related with them at first glance. However, we think that following elements are mandatory in all discipline, for both effective study and research.

- Knowledge and understandings on characteristics of information and methods for their representations. (A1)
- Knowledge and understandings on basic principles of computers and information technology, along with what they can / cannot do. (A2)

- Knowledge and understandings on organizations of computer networks and information communicated over them. (A3)

3.2.2 Generic skills

Generic skills are developed through study of various subjects, and generic skills coming from those subjects will largely overlap one another. Below we list generic skills likely to be developed from informatics education, without considering overlaps.

- Skills to read text documents, understand their points, and grasp their logical structure (or lack of structure). (B1)
- Skills to write text documents which are clear, logical and well-structured. (B2)
- Skills to organize / store / retrieve / analyze / create information using appropriate tools. (B3)
- Skills to exploit useful models such as state transition diagrams or data flow diagrams. (C1)
- Skills to gather / handle qualitative / quantitative data for solving problems. (C2)
- Skills to grasp interrelationships among various tasks and to work out a plan to execute those tasks. (D1)
- Skills to describe procedure and / or describe program codes based on those descriptions. (D2)
- Skills to be engaged in group works, including communication / presentation skills required for the task. (E1)
- Skills to discover / describe / analyze problems, along with skills to work out for solutions. (G1)
- Skills to break down a problem into sub-problems and to grasp relationships among them. (G2)

3.2.3 Attitude and intentionality

In the area of attitude and intentionality, there will be even larger overlaps among subjects; we list elements that seems to be related with informatics education.

- Attitude to distinguish between subjectiveness and objectiveness, along with attitude toward meta recognition. [3] (F1)
- Attitude to think and judge logically based on objective information. (F2)
- Attitude to understand standpoint of others and to respect them. (E2)
- Attitude to consider information ethics and take responsibilities as a citizen on the network. (E3)
- Attitude to take leadership or to follow the leader as necessary. (E4)
- Attitude to study or investigate proactively toward solution of own problems. (G3)

3.2.4 Integrated learning experiences and creative thinking abilities

With respect to integrated learning experiences and creative thinking abilities, a MEXT's document explains as: "Those are abilities to integrate one's previously acquired knowledge, skills and attitude, and apply those to their new problems toward the solution." When reformulated in the context of informatics education, they could be stated as follows.

- Abilities to solve one's own problems using their information-related knowledge, skills and attitude. (G4)

[3] Meta recognition means recognization of one's own behavior or thinking process in an objective manner.

3.3 List of Topics to be Covered by K12 Informatics Education

3.3.1 Relation of the List with High-school Curriculum

We have re-organized the above lists by topic category, whose result is shown in Table 1. Interestingly, the list is generally harmonized with "ability to make use of information" explained in section 2.1; it seems that the committee[4] was successful in forecasting our need for informatics education, including those for higher education. Therefore, our contribution here is that our list is more precise and discussion on their extent and depth is included.

In the following discussions, topics to be covered in high school's mandatory and elective courses are marked as [M] and [E], respectively. Note that [E] does not mean that the topic is for IT major. Please remember that our list originates from "bachelor's abilities," so they are for college applicants in both "Bun-kei" (social / cultural major) and "Ri-kei" (STEM major), although somewhat geared toward Ri-kei.

Another point is that [M] parts are learned by every citizens (today almost all people go to high school in Japan). Those topics should be covered by informatics education through elementary school to high school (compulsory education part is discussed later).

3.3.2 Principles of Information and Computers

[M] All part of A1 and A3 should be learned. As to A2, basic part — how computer works and primitive programming experience (use of simple loops and conditionals) — should be covered.

[E] Advanced part of A2 — what computers can achieve in general, more advanced programming, and basic design of information systems — should be covered.

Table 1: Goals for Informatics Education

A. Principles of Information and Computers
A1. Knowledge and understandings on characteristics of information and methods for their representations. A2. Knowledge and understandings on basic principles of computers and information technology, along with what they can / cannot do. A3. Knowledge and understandings on organizations of computer networks and information communicated over them.
B. Organizing and Creating Information
B1. Skills to read text documents, understand their points, and grasp their logical structure (or lack thereof). B2. Skills to write text documents which are clear, logical and well-structured. B3. Skills to organize / store / retrieve / analyze / create information using appropriate tools.
C. Modeling and Analysis
C1. Skills to exploit useful models such as state transition diagrams or data flow diagrams. C2. Skills to gather / handle qualitative / quantitative data for solving problems.
D. Planning and Procedural Thinking
D1. Skills to grasp interrelationships among various tasks and to work out a plan to execute those tasks. D2. Skills to describe procedure and / or build program codes based on them.
E. Communication and Cooperation
E1. Skills to be engaged in group works, including communication / presentation skill required for the task. E2. Attitude to understand standpoint of others and to respect them. E3. Attitude to consider information ethics and take responsibilities as a citizen on the network. E4. Attitude to take leadership or to follow the leader as necessary.
F. Logicality and Objectiveness
F1. Attitude to distinguish between subjectiveness and objectiveness, along with attitude toward meta recognition. F2. Attitude to think and judge logically based on objective information.
G. Problem Solving
G1. Skills to discover / describe / analyze problems, along with skills to work out for solutions. G2. Skills to break down a problem into subproblems and to grasp relationships among them. G3. Attitude to study or investigate proactively toward solution of own problems. G4. Abilities to solve one's own problems using their information-related knowledge, skills and attitude.

3.3.3 Organizing and Creating Information

[M] All part of B1 and B3 should be covered. As to B2, basic part — creating logical reports and presentations — should be covered.

[E] Advanced part of B2 — designing and creating complex / structured contents (such as Web sites, research paper, or record of a series of group meetings) should be covered.

3.3.4 Modeling and Analysis

[M] Basic part of C1 — use of simple continuous or discrete models and simulation over them — should be covered.

[E] Advanced part of C1 — more large / complex models and simulation in problem solving context — should be covered. C2 includes database, and should be covered in problem solving context.

3.3.5 Planning and Procedural Thinking

[M] Basic part of D2 should be covered along with basic part of A2; procedural thinking and program coding should be tightly interrelated.

[E] D1 should be learnt in the context of actual group work and problem solving. Advanced part of D2 should be covered with advanced part of A2 (programming).

3.3.6 Communication and Cooperation

[M] All of E2 and E3 should be learned. Basic part of E1 — attending to group communication and network communication, performing presentation — should be covered.

[E] E4 should be learned; awareness to leadership should be important in global society. Advanced part of E1 — communication and group work toward explicit outcomes — should be covered.

3.3.7 Logicality and Objectiveness

[M] Basic part of F1 — subjective / objective distinction — should be covered in information ethics and communication attitude context.

[E] Advanced part of F1 — meta recognition — and all of F2 should be covered, perhaps in the context of logical discussion and paper writing.

3.3.8 Problem Solving

[M] G1 and G2 should be covered. G1 corresponds to basic problem solving process, G2 represents MECE breakdown of problems.

[E] G3 and G4 should be covered; it is also related in problem solving in general, and is a preparation toward higher education.

4 Relation to Compulsory Education

So far, we have only discussed about what should be achieved after students finished high school mandatory or elective course; we have not touched about how "before high school" should be. About this topic, some of the authors have previously published a paper titled "Systematic ICT Education Throughout Primary and Secondary Schools: Necessity and Curriculum Proposal[3]," and curriculum proposal explained there includes elementary and junior high school curriculum. We briefly explain our position here.

We have proposed that, in elementary schools, informatics education shall be implemented in existing subjects. For example, programming experiences shall be provided in math subject, and computer text input and editing shall be incorporated in Japanese language subject. The reasons are (1) many subjects are tightly interwouned at elementary school stage, and thus it will be undesirable to teach informatics education separately from other subjects, and (2) repeated (spiral) curriculum will be suitable for elementary-level informatics education, so the mixed contents will be suitable.

We have proposed that, in junior high schools, "information study" shall be implemented as an independent subject as in (senior) high schools. This new subject is expected to achieve approximately the same level as current high school "information study" classes' mandatory part (that is, intersection of "Society and Information" and "Science of Information"). Additionally, computer sensing and control (as contained in current "technology and home economics" in jonior high schools) and programming basics and elementary algorithms (as contained in "Science of Information" in high schools) shall be also included. When those contents are covered in junior high school stage, high school can handle more advanced topics.

Above are somewhat ideal case; we know that installing informatics education in elementary school curriculum or adding new subject in junior high school will not be easy, and we might have to proceed with "information study" subject solely in high school in practice. The list in the previous sections are designed with such situation in mind, and they are based on "abilities needed to proceed to higher education" anyway. However, we well be happy if some systematic informatics education on elementary and junior high school; then high school informatics education will become more successful and college education will be more effective.

5 Summary

Systematic informatics education in Japan has started when the government defined its goal as "ability to make use of information," and added new "information study" subject in high school curriculum, which was in 2003. Although its implementation has many problems currently, activities toward its reform are now in place. In this paper, we reviewed contents of K12 informatics education, using "bachelor's abilities" as a reference base. Outcomes of the review is a list of topics which should have been learned before students proceed to higher education. From the process, we have confirmed that the list are not apart from "ability to make use of information" noted above. We also discussed placement of compulsory education. We are hoping that systematic informatics education will become helpful to young people's life and future of our society, both in Japan and in this global world.

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