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Survey and Analysis of Computing Education at Japanese Universities: Informatics in General Education*

Tetsuro KAKESHITA[1], Naoko TAKAHASHI[2], Mika OHTSUKI[1]
[1]*Faculty of Science and Engineering, Saga University, 840-8502, Saga, Japan*
[2]*Faculty of Economics, Kokugakuin University, 150-8440, Tokyo, Japan*
e-mail: kake@is.saga-u.ac.jp, n.takahashi@kokugakuin.ac.jp, mika@is.saga-u.ac.jp

Abstract. We conducted the first nationwide survey of computing education at Japanese universities in 2016. In this paper, we report the survey result of informatics in general education for all students at a university or a faculty. The survey covers various aspects including program organization, quality and quantity of educational achievement, students, teaching staff and computing environment. 739 answers are collected from 530 universities in response to the survey. The answers cover 70.5% of the Japanese universities, and approximately 81.6% of the 649 universities that responded to the survey. The Information Processing Society of Japan (IPSJ) and the Japanese Ministry of Education (MEXT) will utilize the survey result to develop a new computing curriculum standard J17 and national policy of computing education respectively.

Keywords: informatics in general education, web-based survey and analysis, college level education, curriculum design, quality assurance in education.

1. Introduction

Computing education is essential at modern universities, since IT (Information Technology) is necessary to enhance ability of an individual and is expected as a powerful innovation driver through integration with various technologies (CS for ALL, n.d.; European Committee, 2018). There are four types of computing education in Japanese universities:

A. Computing education at a department or a course majored in computing discipline.

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B. Computing education at a non-IT department or a course as a part of their major field of study.
C. Informatics in general education for all university students typically at the first or second academic year.
D. Computing education to obtain high school teacher license on computing subjects.

We conducted the first nationwide survey of Japanese universities on computing education in 2016 (Kakeshita, 2017). The survey is composed of four survey types A through D described above as well as the survey type E for educational computer system.

In this paper, we shall report and analyze the survey results regarding informatics in general education (Kawamura, *et al.*, 2015; Kawamura, *et al.*, 2016), i.e. survey type C. Informatics in general education is implemented as a common subject for all undergraduate students belonging to a university or a faculty in Japan. Although this survey is focused on Japanese universities, such type of general computing education is expected internationally (Informatics Europe and ACM Europe, 2013; Libeskind-Hadas, 2015). Therefore, our survey and analysis result will be of interest to a wide range of the readers outside of Japan.

Our survey on educational contents is based on J07-GEBOK[**] (Kawamura, 2008), introduced in Section 2.2, which is developed by Information Processing Society of Japan (IPSJ) as a guideline for college level informatics in general education. J07-GEBOK was developed without a detailed survey of college level informatics in general education. Our analysis is necessary to develop realistic curriculum guideline and accreditation criteria to improve informatics in general education at university.

IPSJ will utilize our survey result to develop various types of college level computing education guidelines including the new J17 curriculum standard (IPSJ, 2018). The Japanese Ministry of Education (MEXT) will utilize the survey result to improve the national policy of computing education in Japan.

2. Survey Plan

2.1. *Survey Questions*

The following is the list of questions for survey type C. As the reader can understand from the list, our survey covers various aspects of computing education by considering the Japanese standards for establishment of universities and our experience of accrediting computing programs in Japan:

- Name of university and/or faculty.
- Respondent standpoint.
- Program organization:
  - Day time, night or remote program.

[**] GEBOK – General Education Body of Knowledge

  - Required number of credits for graduation.
  - Number of subjects provided.
- Quality and quantity of educational achievement:
  - See Section 2.2 for detail.
- Enrolled students:
  - Regular academic years of the program.
  - Number of students.
- Teaching staff:
  - Number, educational background, current specialized field, tenure of faculty members.
  - Number and workload of support staff.
  - Number and workload of teaching assistant students.
- Computing environment:
  - Educational computer system.
  - Student's own PC and utilization at class.
  - Educational programming language.
- Other topics:
  - Strength and future plan of the program.
  - Utilization of IT certification and qualification.
  - Special remarks.

2.2. *Survey of Quality and Quantity of Educational Achievements*

The survey of quality and quantity of educational achievements is the core of our survey. We define six achievement levels for knowledge and skill represented in Table 1. These levels are used to describe quality of education.

Table 1
Knowledge and Skill Level Definition

Level	Knowledge Level Definition	Skill Level Definition
0	Not taught (unnecessary or already taught at general computing education)	
1	Not taught because of the time limitation or because the level of the contents is too high	Taught at class with simple exercise
2	Taught at class. Students know each term	Taught at class with some exercise. Students can perform the topic if detailed instruction is provided
3	Taught at class. Students can explain the meaning of each term	Taught at experiment with more complex exercise. Students can perform the topic with simplified instruction
4	Taught at class. Students can explain relationship and/or difference among related terms	Students perform combined research project containing the topic so that the students can autonomously perform the topic
5	Taught at class or graduation research project. Students can teach related domain or subject of the terms to others	Students perform combined research theme containing the topic. Students can teach how to perform the topic to others

We utilize J07-GEBOK (Kawamura, 2008) in order to define knowledge areas of the informatics in general education. J07-GEBOK is proposed by the Information Processing Society of Japan (IPSJ) as a common body of knowledge for informatics in general education. The following is the list of areas of J07-GEBOK. Each area contains several learning units:

- Information and Communication.
- Digitalization of the Information.
- Computing Elements and Structure.
- Algorithms and Programming.
- Data Modeling and Operation.
- Information Network.
- Information Systems.
- Information Ethics and Security.
- Computer Literacy.

J07-GEBOK is a subset of the common BOK utilized for other survey types A, B and D. This is because the subjects assigned for informatics in general education are quite limited due to the restriction of teaching staff and the number of students learning the subjects.

A university or a faculty answers expected knowledge and skill levels of the students at each area of the BOK. At the same time, the organization answers the total number of students taking the subjects taught in each area.

As a result, quality and quantity of education at the organization is summarized using J07-GEBOK.

2.3. *Survey Process*

We prepared the survey in October 2016. We defined the survey questions and set up the web-based survey system (Kakeshita and Ohtsuki, 2011). We utilized the web-based survey since we did not exactly know the actual organization for this survey in advance. After preparing various documents such as user manual and detailed instruction of the survey questions, we sent the formal request letter to all universities in Japan with a reference letter from the Japanese Ministry of Education in order to increase the response rate.

The survey was executed for two months starting at the beginning of November 2016. Each survey responder must first register to the web system and then answer the questions listed in Section 2.1. We also provide FAQ and independent answers for the questions from the responders.

After closing the survey, we reviewed the collected answers and requested the responders for possible correction of the incomplete answers.

3. Overview of Informatics in General Education

3.1. *Response Rate Analysis*

We collected 739 answers from 69 national universities, 58 public universities, and 404 private universities in response to the survey type C. 447 registrations are from entire universities and 292 registrations are from faculties or campuses of a university. The number of responded universities are 531, corresponding to 71.8% of the universities in Japan. This demonstrates the reliability of our survey.

The number of universities responded to at least one survey type A–E is 649. This implies that 81.8% of the responded universities provide informatics in general education and this type of computing education is widely executed in Japanese universities.

3.2. *Respondent Standpoint*

We asked the survey respondents about their position within the university. We made the question to clarify whether they are secretariat staff or faculty members. 69.9% of the respondents were secretariat staff. Since informatics in general education is administrated by a university or a faculty, a secretariat staff may have answered the questions on behalf of the faculty members in charge. Other respondents are university officials, representatives of common education, and representatives of educational computer center. It is commonly observed at Japanese universities that representatives of common education belong to another faculty and the secretariat staffs are usually working on administration of common education as a delegate of the representative.

4. Program Organization

In the class formats of the subjects offered as required credits of informatics in general education, most of them are provided as lectures. The second choice is an exercise, followed by training, practice, and laboratory work. The number of classes is distributed from 0 to more than 100 at large-scale universities. Here, we report the cases of lecture and exercise.

There are 263 answers, or 35.5% of the responses, stated that they have no required credits for informatics in general education. Many of such universities provide computing education as elective subjects. This indicates that 64.5% of the Japanese universities have required credits for informatics in general education.

Such information provides realistic restrictions to develop a curriculum guideline for informatics in general education.

4.1. *Lecture Courses (Required)*

For the number of required credits of the subjects provided as a lecture, 63.3% of the answers are 0, while 16.6% of the answers are 2 credits. There was a computing department that responded with a maximum value of 18 credits. We also have medical universities that answered with the number of lecture hours instead of the number of credits. In this case, we converted the number of hours to the number of credits since 1 credit corresponds to 11.25 lecture hours.

For the total number of required lectures, 39.5% of the answers was 0, 22.7% of the answers was 1. The maximum value of required subjects was 50 from a large-scale comprehensive private university. Fig. 1. represents the number of responses to each answer excluding 0.

4.2. *Exercise Subjects (Required)*

For the number of required credits for the exercises, 64.8% of the answers was 0, 15% of the answers was 2 credits. This can be interpreted that teaching of an exercise require extensive student guidance so that it is more difficult for a university to provide computing exercise to all their students. The maximum value was 14 credits at a university majored in social science with 800 first-year students. On the other hand, for the number of required seminar subjects, 15% of the answers were for 1 and 2 subjects respectively. The maximum value was 44 credits at a university majored in health care with 100 first-year students.

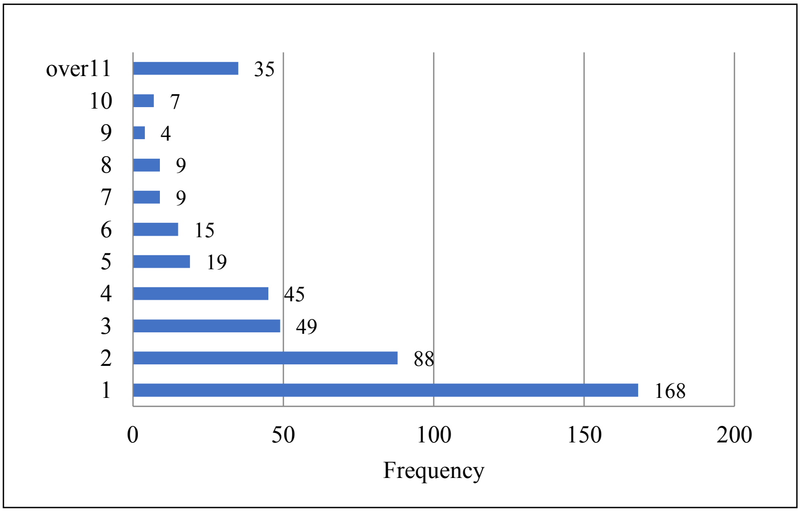

Fig. 1. Total Number of Lectures.

4.3. *Number of Credits of Elective Subjects*

For the number of credits required for graduation for elective computing subjects, 61.3% of the answers was 0 credits, and 11.8% of the answers was 2 credits. The answer includes all subject formats such as lecture, exercise, training, practice and laboratory work. Like the number of credits for the required subjects, the most popular answer was 2 credits.

5. Quality and Quantity of Educational Achievement

5.1. *Overview of the Survey Areas*

In the investigation of educational content, we asked universities to respond the expected level and number of courses based on the areas of J07-GEBOK. At the same time, we allowed them to select items from the reference standard of informatics (Hagiya, 2015) which defines the contents of computing education in Japan. Organization of the reference standard is summarized in Table 2. The reference standard is composed of 6 sections, 19 domains and 81 areas. The numbers within the parenthesis in Table 2 are the number of areas belonging to the section or the domain. Since J07-GEBOK is a small subset of the reference standard of informatics, we expected that very few universities teach contents of the reference standard. However, we found that all the areas are taught at some universities through the survey.

Table 2
Organization of the Reference Standard of Informatics

Section	Domain
(A) General Principles of Information (6)	
(B) Principles of Information Processing by Computers	Information Transformation and Transmission (4), Information Representation, Accumulation and Management (4), Information Recognition and Analysis (4), Computation (6), Algorithms (8)
(C) Technologies for Constructing Computers that Process Information	Computer Hardware (3), I/O Device (4), Fundamental Software (3)
(D) Understanding Humans and Societies that Process Information	Process and Mechanism for Information Creation and Transmission (2), Human Characteristics and Social System (3), Economic System and Information (2), IT-based Culture (2), Transition from Modern Society to Post Modern Society (2)
(E) Technologies and Organizations for Constructing and Operating "Systems" that Process Information in Societies	Technics for Information System Development (7), Technics to Obtain Information System Effect (6), Social System Related to Information (2), Principle and Design Methodology for HCI (4)
Competence	Professional Competency for IT Students (3), Generic Skill for IT Students (6)

We adopted the same definition of levels, as illustrated in Table 1, and BOK, illustrated in Table 2 along with J07-GEBOK, throughout the survey types A to D in order to enable mutual comparison of the different survey types. Such comparison is important to understand relationship among different survey types.

There were 253 responses regarding the investigation of educational content and levels, which corresponds to 34.2% of the responses.

The universities are mainly focused on the areas in J07-GEBOK, but the second most focused domain is "Generic Skill for IT Students" defined in Table 2. The generic skill contains creativity, logical and computational thinking, problem discovery and solving, communication and presentation, team work and leadership, and self-learning. It is well recognized that computing education is suitable to learn such generic skill.

5.2. *Effort Analysis at Each GEBOK Area*

As for the areas of J07-GEBOK, the degree that each university is focusing on is defined using the effort value. The effort value of an area is defined by the multiplication of the number of students learning the area and the average level of the students. We thus define two types of effort values corresponding to knowledge and skill.

Fig. 2 represents the effort values at each area of J07-GEBOK. The analysis is useful to clarify the current effort distribution of the universities for the areas. The areas are sorted in descending order of the knowledge effort values. Even if the values are arranged in terms of knowledge and skill in the same order, computer literacy is ranked at the first place. The effort for the "data modeling and operation" is low. This is the same result as our previous investigation (Kawamura, 2015). We also observe that the skill effort is generally lower than the knowledge effort. The reason can be considered that teaching skill needs more effort than teaching knowledge since exercise becomes necessary.

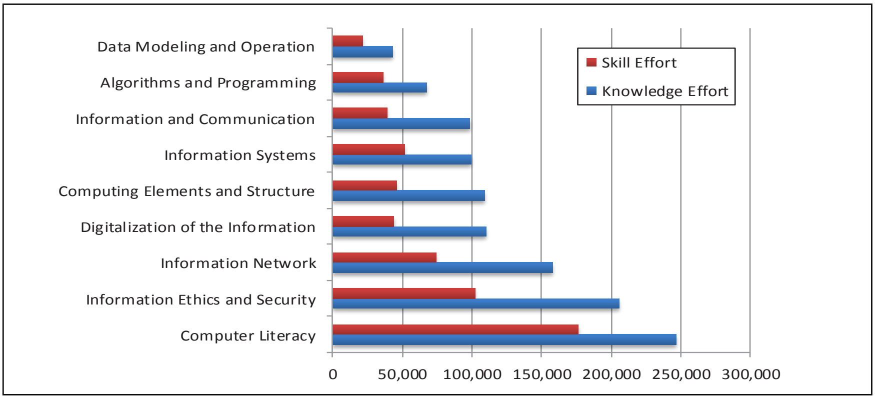

Fig. 2. Effort Values of Each Area of Informatics in General Education.

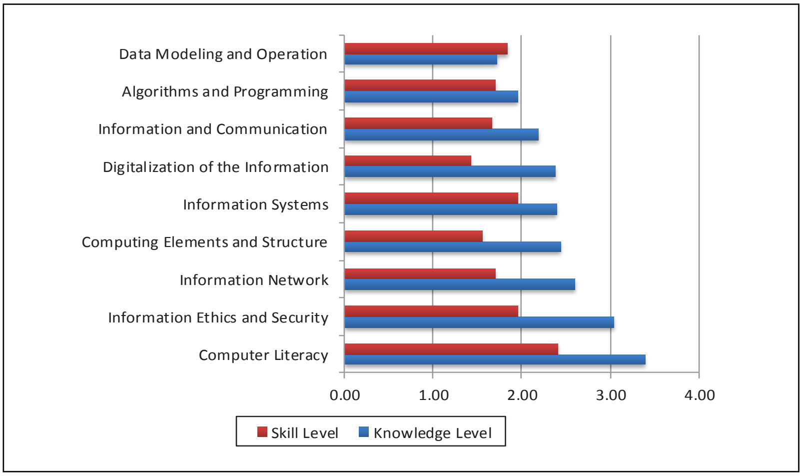

Fig. 3. Average Level of Each Area of Informatics in General Education.

5.3. *Average Level at Each GEBOK Area*

Fig. 3 represents average knowledge/skill levels at each GEBOK area. By this, the achievement levels can be analyzed in the current informatics in general education. Taking this into consideration, the requirement level can be defined at each area of general information education for the new curriculum recommendation. In addition to this, effort distributions of knowledge and skill in each GEBOK area can be utilized as a measure of the number of credits (or lecture hours) to be assigned to the areas.

A realistic curriculum can be designed by assigning appropriate number of hours and requirement level for each area considering these analyses' result.

5.4. *Answer Distribution of Each GEBOK Area*

Fig. 4–Fig. 12 represent the distributions of the number of responses at each GEBOK area. The readers can refer to Table 1 for the definition of knowledge and skill levels.

The responses of "Information and communication", "Digitization of information", "Elements and composition of computing", "Information Network" and "Information Systems" have a similar trend. Skill is "not taught" in most of the answers, but knowledge level is separated at level 0 (not taught) and level 2. At level 1, there is more skill than knowledge (Fig. 4–Fig. 6, Fig. 9, Fig. 10). The "Algorithm and programming" and "Data modeling and operation" resulted in many level 0 (not taught) responses, which are different from other areas (Fig. 7, Fig. 8).

On the other hand, for "Computer literacy" (Fig. 12), the most frequent response for skill was level 2, and level 4 for knowledge. The most frequent response was level 1 for skill, and level 3 for knowledge in case of "Information Ethics and Security" (Fig. 11).

Considering these results, we made the following revision to develop J17-GEBOK in J17 (IPSJ, 2018). For "Data modeling and operation" with the smallest effort, we decided to change the area name to "Database and data modeling" and treat it mainly in the database. We changed the name of "Information system" to "Society and information system" because of strong relationship with society.

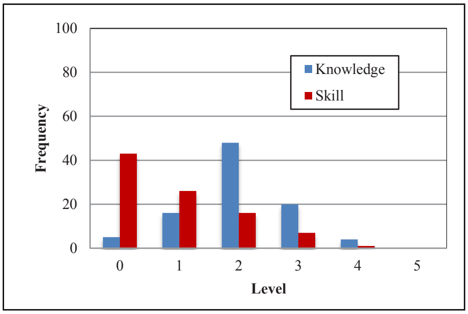

Fig. 4. Answer Distribution:
Information and Communication.

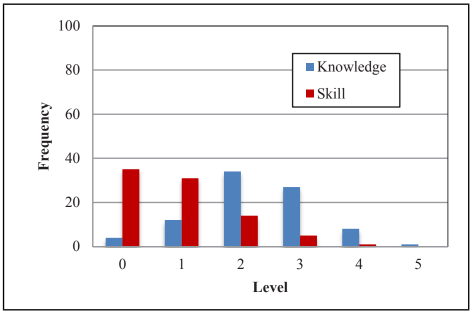

Fig. 5. Answer Distribution:
Digitalization of the Information.

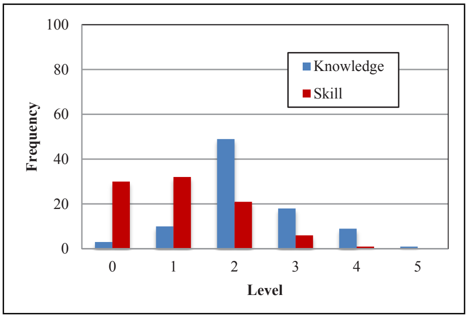

Fig. 6 Answer Distribution:
Computing Elements and Structure.

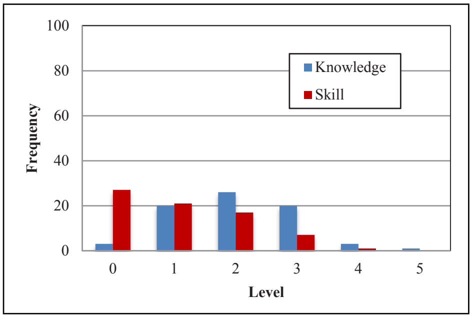

Fig. 7. Answer Distribution:
Algorithm and Programming.

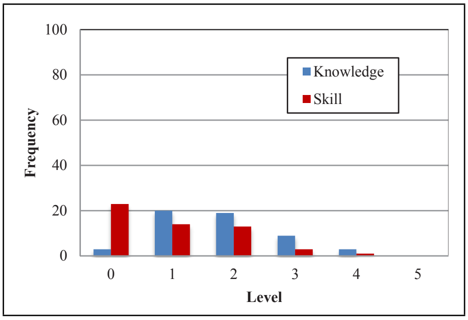

Fig. 8. Answer Distribution:
Data Modeling and Operation.

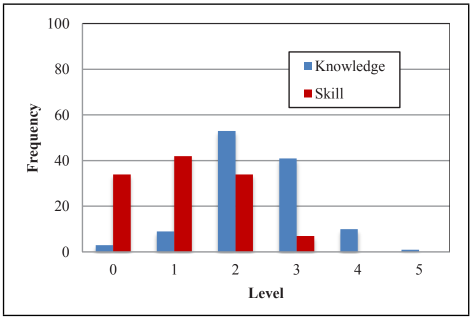

Fig. 9. Answer Distribution:
Information Network.

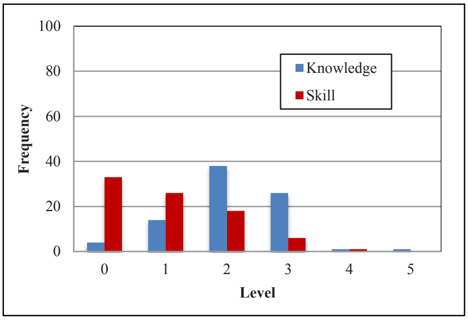

Fig. 10. Answer Distribution:
Information Systems.

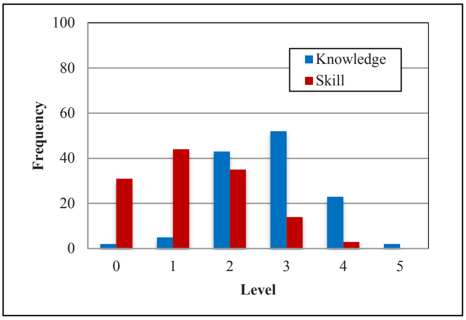

Fig. 11. Answer Distribution:
Information Ethics and Security.

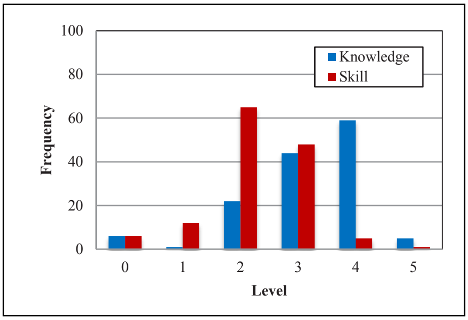

Fig. 12. Answer Distribution:
Computer Literacy.

"Computer literacy", which contains basic computer operation and application operation, is deemed to be handled in K-12 education at primary and/or secondary school so that it was dealt with as supplementary (pre-requisite) in J07. However, because the devoted effort to computer literacy is the largest, we decided to define an area called "Academic ICT Literacy" in J17 as the ICT skills to be handled at the higher education stage in combination with liberal arts education in a wide range of fields.

6. Status of Students and Faculty Members

6.1. *Standard Target Students and Number of Courses*

For the program's standard target students, 284 (38.5% of the responses) programs are provided for the first-year students, while 334 (45.3%) programs are provided for the first and second-year students. However, we have 15% of the responses that included target students over third-year students. There is a need to assess whether informatics in general education is required for specialized courses and whether they should be mastered by fourth-year students.

The capacity of the first-year students at the universities responded to the survey is 416,062 as a total. The student capacity is between 100 and 500 at 49.5% of the responded universities, which is the most frequent answers.

The total number of male students was 137,633, while the total number of female students was 109,479. The total number of students was 247,112, which is equivalent to 59.4% of the capacity of the first-year students. We estimate that 247,000 students, approximately half of the first-year students estimated from the school basic survey (MEXT, 2016), learn informatics in general education, which indicates the importance of informatics in general education.

6.2. *Status of Faculty Members in Charge*

The general situation of the faculty members teaching informatics in general education courses is depicted in Table 3. Their current majors are determined by the faculty members based on whether their major field is included in the area "Computing" of the Grants-in-aid for Scientific Research.

Compared with the faculty members belonging to computing departments (Kakeshita, 2018), the ratio of full-time faculty members who graduated from a computing department and whose current major is computing is low. On the other hand, the ratio of employees who graduated from computing departments and whose current major is computing is higher for the case of part-time faculty members outside of the university. We also observe that the ratio of part-time faculty members outside of the university is 32% among all classifications of faculty members. This implies the shortage of full-time faculty members majored in computing discipline within the university.

Like the specialized computing education, faculty members with specialized knowledge of computing education should also be deployed for the faculty members in charge of informatics in general education.

We believe that although there are difficulties from the university's side, but improvement is desirable in the future.

Table 3
Faculty Members Teaching Informatics in General Education

Category of Faculty Members	Total	Faculty Members who Graduated a Computing Department	Faculty Members whose Current Major is Computing
Full-time Faculty Members with Tennure	2,467	550 (24.1%)	318 (13.4%)
Full-time Faculty Members without Tennure	361	77 (21.3%)	130 (41.1%)
Part-time Faculty Members belonging to other Department	1,247	282 (22.6%)	443 (35.5%)
Part-time Faculty Members outside of the University	1,874	567 (30.6%)	891 (48.2%)
Total	5,849	1,476	1,782

6.3. *Committee in Charge*

The situation of the committee in charge of the administration of the general education is shown in Table 4. As a common education at the university or faculty level, we asked for the existence of a committee to oversee general computing education. 40.6% established a formal committee based on the campus regulations. However, 54.1% responded that organizations such as committees do not exist particularly. In our previous survey, about 60% responded that they have an administrative committee so that we have a similar result.

7. Educational Environment

7.1. *Educational Computer System and Student PC Utilization*

We asked for answers regarding educational computer systems which can be used for informatics in general education. 554 (74.9%) responded that there were PCs that could be used for university courses, while 173 (23.4%) responded that there was no PCs prepared that could be used for university courses mainly due to the shortage of financial support.

Table 5 represents PC utilization status possessed by the students. 83.2% of the universities answered that purchasing/owning a PC was voluntary for a student, while 6.8% answered that a student is required to purchase PC at the university level. Al-

Table 4
Committee in Charge

	# of Answers
Decisions made at informal meetings etc.	39
Established formal committee based on school regulations	301
None	400

Table 5
Utilization of Student PC

Utilization	# of Answers
All Students of the University must have PC	50
All Students of the Faculty must have PC	24
All Students of the Department/Course must have PC	13
Students are recommended to purchase PC	37
Purchasing of Student’s own PC is optional	616
Total	740

though the most frequent case is purchasing of student's own PC is optional, many of the students are willing to purchase their own PC when they enter the university. This is because many educational contents are provided online, and students often prepare and submit various materials such as homework and job hunting application using their own PC.

7.2. *LMS*

Learning management system (LMS) is utilized at many universities in order to automate various educational activities such as report submission, online testing, student survey etc.

For the LMS utilization status, 47.6% responded that they did not utilize LMS, while 26.9% answered that they utilize an LMS based on commercial products. Regardless of whether the teachers actively utilize online submissions, there were approximately 100 responses which said that LMS was not used. Although further investigation is expected for the specific reason of this, we guess that individual faculty members accept student report via e-mail.

We obtained 290 responses, 75% of the cases which utilize LMS, that stated the product names. Table 6 summarizes the result of the LMS product names having more than 10 votes. Moodle occupies majority of the responses. We also received approximately 10 responses that two types of LMS are combined and used together.

7.3. *Educational Programming Languages*

We collected five educational programming languages from each university or faculty for which the students' achievement level is high. Table 7 illustrates popular programming languages for the informatics in general education calculated using the collected data. The score of each language is evaluated as a weighted sum of the answers. The

Table 6
Popular LMS Product

LMS Product Name	# of Answers
Moodle	92
WebClass	27
manaba	25
Blackboard	19
Course Power	13
Universal Passport	10

Table 7
Popular Programming Languages for Informatics in General Education

	Language	Score		Language	Score
1	C	243	6	Ruby	48
2	Visual Basic/VBA	209	7	Fortran	35
3	Java	178	8	SQL	33
4	JavaScript	126	9	Python	25
5	C++	55	10	PHP	24

weight of a language is estimated using the rank, between 1 (5-th place) and 5 (1-st place), supplied by the university or the faculty. Although C language is the most popular as in the case of computing department, the second most popular language, Visual Basic, is different from the case of computing department.

7.4. *Utilization of IT-related Certification*

We obtained 59 responses, which was equivalent to 8% of the total responses. We found 13 IT certifications among the responses having two or more responses. They are depicted in Table 8. IT Passport Examination (IPA, n.d.), which covers a common and basic knowledge for utilizing IT, is the most popular examination and its share is 34.2% of the responses while Microsoft Office Specialist occupies 19.1%. This result was as expected since IT Passport Examination is authorized by the Ministry of Economy, Trade and Industry of Japan.

There were 14 responses that encouraged the acquisition of the IT certification since they are useful for job hunting for the students.

Table 8
Utilization of IT Certification

Qualification Name	# of Answers
IT Passport Examination (ITEE) by a Japanese government agency IPA	25
Microsoft Office Specialist (MOS)	14
Nissyo PC qualifying examinations by Japan Chamber of Commerce and Industry	5
.com Master	2
ICT Proficiency	2
Information Security Management	2

8. Concluding Remark

We can observe the entire picture of the computing education at Japanese universities through the survey. Although several problems are discovered, IPSJ is willing to improve the current situation through development of new computing curriculum standard J17 and cooperation with Ministry of Education, Japan.

Among the universities that responded to our survey, 530 universities (81.6% of the responded universities) provide informatics in general education, and 247,000 students (approximately half of the first-year students) are learning the course. This showed the importance of informatics in general education in Japan. However, while 64.5% responded that more than 1 credit is assigned, 87.6% responded that courses were offered with more than 1 subject, showing a discrepancy in the responses. There is a need to verify the cause of the difference in responses in the number of credits and subjects. Also, the knowledge and skill required for the exercise was designated at level 5, and there were universities with 50 subjects for the informatics in general education, and we obtained responses that we did not expect. We would like to clarify the meaning of these responses with additional investigations.

In the effort analysis including the reference standard for informatics, the second most common educational contents are “Generic Skill for IT Students”. We are planning to investigate relationship between computing education and generic skill training as a future research.

This survey was conducted using different methods than the ones used in our previous surveys during 2013 and 2014 (Kawamura, 2015). Thus, we cannot compare in a simple manner. Although equivalent results are obtained for some topics, such as the implementation rates of informatics in general education, there are significant differences in the position of the respondents and usage rate of LMS. As for the result of the educational content, the definitions of the knowledge and skill levels are different. Thus, there is a need to compare two survey result for reasonable interpretation of the difference.

IPSJ typically revises computing curriculum standard every 10 years. Conduction of a similar survey is expected every 5 years in order to observe the current status of computing education and to prepare the next curriculum standard to improve computing education.

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T. Kakeshita is an associate professor at Computing Division, Saga University, Japan. He received his Ph.D. degree in Computer Science from Kyushu University, Japan in 1989. His major research interests include quantitative analysis of ICT education and ICT certification, and complexity analysis of database and software systems. He received an excellent educator award from Information Processing Society of Japan (IPSJ) in 2013. He joined many activities such as IPSJ educational activity, Certified IT Professional Certificate (CITP), accreditation at Japan Accreditation Board for Engineering Education (JABEE) and ISO standard development (ISO/IEC JTC1/SC7/WG20).

N. Takahashi is a professor at Faculty of Economics, Kokugakuin University, Japan. She majored in mathematics at the university. After graduation, she worked at Fujitsu Ltd. as the first female SE. Next, she opened a PC school at an IT company. After independence, she worked on technical writing and taught PC skills and information systems at university. Since she worked at university, she specializes in computing education. She joined many activities such as IPSJ educational activity, Commitee of Informatics in General Education, Commitee of the entrance exam with an Informatics subject.

M. Ohtsuki is a senior lecturer at Computing Division, Saga University, Japan. She received her Ph.D. from Kyushu University in 1999. Her major research interests include computer aided ICT education, and software development methodologies including software testing. She is a committee member of JaSST (Japan Symposium on Software Testing) in Tokyo and is a commissioner at ASTER (Association of Software Test EngineeRing). She published several books about software development tools such as CVS, CppUnit etc.