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Requirement Analysis of Computing Curriculum Standard J07 and Japan Information Technology Engineers Examination Using ICT Common Body of Knowledge

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Abstract: Information Processing Society of Japan (IPSJ) has announced the Computing Curriculum Standard J07 which is compatible with the Computing Curricula 2005 (CC2005) Series proposed in the United States. Both J07 and CC2005 are composed of five major domains, CS, CE, SE, IS and IT, each of which is developed by a different community so that the relationship among these domains is not clear. In this paper, we analyze each body of knowledge (BOK) of the domains and map them into the ICT common body of knowledge (ICTBOK) which we have proposed in our previous paper. We also analyze Japan Information Technology Engineers Examination (JITEE) whose syllabus is published for each of 12 examination categories provided by the Japanese government. We estimate the degree of importance and the requirement level in terms of the 155 ICTBOK areas for each J07 domain and JITEE examination category by utilizing the mapping. Moreover we estimate the similarity and the difference among them. As a result, the relationship among J07 domains and JITEE examination categories is clarified.

Keywords: requirement analysis, J07, Japan Information Technology Engineers Examination, ICT education, ICT human resource development

1. Introduction

Information Processing Society of Japan (IPSJ) announced the Computing Curriculum Standard J07 [1] as a guideline for college level ICT education. J07 is essentially compatible with the Computing Curricula 2005 (CC2005) [2] developed by ACM, IEEE Computer Society (IEEE-CS) and AIS. Considering the diversity of the computing disciplines, the following five major domains are defined both in J07 and CC2005.

- CS: Computer Science
- CE: Computer Engineering
- SE: Software Engineering
- IS: Information Systems
- IT: Information Technology

Each domain of J07 and CC2005 is developed by a different community for historical reasons so that the body of knowledge (BOK) of each domain is described using a different terminology. As a result, the relationship among these domains is not concrete and clear not only for the society including the industry and the government but also for professors and students of ICT departments. This situation is not desirable for many stakeholders of the computing curriculum.

Industry and the Japanese ministry of industry both realize that ICT (Information and Communication Technology) is necessary for global competition. The Japanese government and the local governments want to increase their business efficiency by developing and operating a digital government. A large number of high level ICT professionals are required to achieve these goals.

IPA (Information Technology Promotion Agency) is a governmental organization and supplies Japan Information Technology Engineers Examination (JITEE) composed of 12 examination categories to visualize entry and middle level ICT professionals. JITEE is a well-known ICT qualification in Japan and over 600,000 examinees take the examination each year.

In this paper, we analyze the BOKs of the five J07 domains and map them into the ICT common body of knowledge (ICTBOK) which we have proposed in our previous paper [3]. ICTBOK is composed of 7 categories, 23 fields and 155 areas; and covers a wide range of knowledge and skill required for ICT professionals. We also analyze JITEE examination categories by making a correspondence between the syllabus of each category and ICTBOK. Thus a clear and concrete analysis becomes possible in order to clarify the relationship among J07 domains and JITEE examination categories.

As of June 2013, there is no ICT examination which directly corresponds to a computing curriculum standard such as CC2005 and J07. IEEE-CS is running CSDP (Certified Software Development Professional) examination based on SWEBOK (Software Engineering Body of Knowledge). J07-CS refers a small subset of SWEBOK since J07-CS is developed for college graduates while SWEBOK is developed for software engineer having 4 years of working experience. IEEE-CS announced on June 2012 that they are going to use SFIA [4] to define the skill of ICT professional and ICT student. The corresponding activity is

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just starting. In this sense, this paper treats a challenging research domain.

The detail of ICTBOK is described in Section 2. The structures of J07 and JITEE are introduced in Sections 3 and 4 respectively. We shall overview the analysis plan in Section 5. In Section 6, we map BOK of each J07 domain into ICTBOK. Then we estimate the degree of importance of the 23 fields of ICTBOK for each J07 domain. The requirement level of each ICTBOK area is also estimated for each domain. We also analyze each JITEE examination category in Section 7 by making the correspondence between ICTBOK and the syllabus of the examination category. We shall compare the analysis results in Section 8.

2. ICT Common Body of Knowledge

ICT common body of knowledge (ICTBOK) is developed to uniformly represent the knowledge and skill of ICT professionals belonging to various job categories and levels [3]. ICTBOK also provides a common vocabulary to define various activities of ICT education such as the requirement and the achievement of an ICT education program. ICTBOK is composed of 7 categories, 23 fields and 155 areas. The readers can find the entire ICTBOK in Appendix A.1.

IPA announces three types of skill standards for ICT professionals [5]. They are

(1) ITSS (skill standards for IT professionals) for people working for IT services industry,
(2) ETSS (embedded technology skill standards) for embedded software engineers, and
(3) UISS (user's information system skill standards) for information system users.

We have analyzed the three skill standards and have defined ICTBOK. ICTBOK also covers the teaching domain of college level ICT education by analyzing and integrating the J07 curriculum standard.

Table 1 represents categories and fields of ICTBOK. Each field in Table 1 is associated by the abbreviation (such as FND) and the number of areas corresponding to the field. In addition to the BOK explained above, ICTBOK also contains the category "competences" expected as a society member. The fields of the competences are developed by the ministry of economy, trade and industry of the Japanese government. The "others" category is defined so that users can add areas if there are some missing areas in ICTBOK.

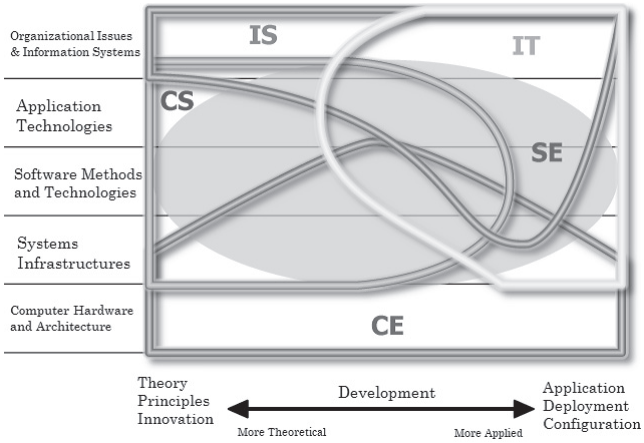
We shall call the Business and Competences categories as non-ICT categories among the seven categories of ICTBOK, while the remaining five categories as ICT categories.

3. Computing Curriculum Standard J07

J07 is composed of six domains, CS, CE, SE, IS, IT and GE [1]. Here GE is a curriculum standard for general ICT education for non-ICT students and is excluded from the analysis of this paper. The other five domains correspond to CC2005 domains with some modifications to adopt the teaching environment in Japan. A conceptual relationship of the domains is illustrated in **Fig. 1**.

The curriculum of a Japanese university is typically composed of three parts: one-year general education, two-year technical education for a specific major domain, and a one-year graduation research project. J07-GE is designed for non-ICT students as a part of their general education. Other J07 domains are designed for ICT students as a part of their technical education. Since the ICT discipline is rapidly growing and J07 is proposed as a guideline for ICT curriculum development, IPSJ does not intend to strictly "define" the ICT curriculum. Instead, J07 defines core units for one-year technical education in ICT as a body of knowledge (BOK) for each domain. Although ICT departments are expected to choose one of the five domains, they can freely design the remaining three-year part of their curriculum.

Among the domains of J07, CS, CE and IT have the same structure. For example, the BOK of the CS domain (J07-CSBOK) is composed of 15 knowledge areas and 138 units. The minimum core coverage time, topics and learning objectives are defined for each unit. If the minimum core coverage time of a unit is greater than 0, the unit is called a core unit. The expected outcomes of



(Initially published in CC2005 and updated in J07)

Fig. 1 Conceptual relationship of J07 domains.

Table 1 Categories and fields of ICTBOK.

Category	Field
Foundations of Computer Science	Fundamental Theory (FND, 7) / Mathematics, Applied Mathematics (MATH, 5) / Computer Architecture (ARCH, 9) / Hardware (HW, 7) / Operating System (OS, 5)
Media, Human Computer Interaction	Multimedia Data Processing (MMDP, 8) / Human Interface (HUI, 3) / Usability (2) / Intelligent System (INTL, 6)
Network and Security	Telecommunication System (Telecomm, 9) / Computer Network (NET, 6) / Web Technology (WEB, 8) / Security (6)
Software Development	Database (DB, 6) / Algorithm and Data Structure (ALGO, 5) / Computer Programming (PRG, 5) / Software Engineering (SWE, 11)
Information System	Project Management (PM, 6) / System Operation and Evaluation (OPR, 8)
Business	Business and Administration (Business, 8) / Communications (COMM, 5) / Society and Ethics (SOC, 4)
Competency	Behavior (3) / Thinking (3) / Teamwork (6)
Others	*Additional fields or areas can be defined by users, if necessary.*

Table 2 Levels and examination categories of JITEE.

Common Career / Skill Framework		Expected Examinee	Categories of Information Technology Engineers Examination
Level 4	Advance Level Knowledge and Skills	IT Professionals who can lead a project	Advanced Level Examination • Information Technology Strategist Examination (ST) • System Architect Examination (SA) • Project Manager Examination (PM) • Network Specialist Examination (NW) • Database Specialist Examination (DB) • Embedded Systems Specialist Examination (ES) • Information Security Specialist Examination (SC) • Information Technology Service Manager Examination (SM) • System Auditor Examination (AU)
Level 3	Applied Knowledge and Skills	Master course graduates majored in IT	Applied Information Technology Engineer Examination (AP)
Level 2	Fundamental Knowledge and Skills	College graduates willing to be IT engineers	Fundamental Information Technology Engineer Examination (FE)
Level 1	Fundamental Knowledge Required of All Workers	All working member of the society	Information Technology Passport Examination (IP)

the student are defined as learning objectives. The topics describe the teaching topics of the unit.

The structures of SE and IS are different from the above.

J07-SEBOK is composed of 17 knowledge areas and 297 units. J07-SE is based on SE2004 [2] except that core time is not defined for each unit. Instead, each unit is assigned to some course whose syllabus contains the weekly plan. The weekly plan also contains the learning objectives for the corresponding unit.

The main components of J07-IS are the learning units (LU). J07-IS is based on IS2002 [2] developed by AIS. 209 LUs are defined in J07-IS. Among them 108 are the core LUs. Each LU is composed of LU#, level, teaching and learning objectives. The level of a LU is between 0 and 5; 0 stands for "does not know," 1 for recognize, 2 for explain, 3 for utilize, 4 for apply, 5 for proficient.

4. Japan Information Technology Engineers Examination

The Japan Information Technology Engineers Examination (JITEE) is a set of examinations provided by the Japanese government [6]. The government has announced Common Career/Skill Framework (CCSF) as a framework to make correspondence among three skill standards for IT professionals and JITEE. JITEE covers various levels of IT knowledge and skill from IT literacy (level 1) to the advanced level for IT engineers (level 4) as illustrated in **Table 2**. As also illustrated in the table, these levels correspond to the expected levels for college students of various backgrounds. J07 corresponds to Level 2 in Table 2, since J07 is designed for a college level ICT education.

JITEE is composed of 12 examination categories. The level 1 examination (IP) is composed of 100 multiple-choice questions to evaluate the examinee's knowledge. The level 2 examination (FE) is also composed of multiple-choice questions. FE examination contains morning and afternoon exams to evaluate the examinee's knowledge and skill levels respectively. The level 3 and 4 examinations (AP and above) also contain morning and afternoon exams to evaluate knowledge and skill. The morning exam is composed of multiple-choice questions, while the afternoon exam is mainly composed of short answer questions to which applicants must write short text. The remaining questions of the afternoon exam requires longer essay describing the examinee's opinion or experience under the specified situation. Thus a 5-year working experience as an IT engineer is typically required to pass the level 4 examinations.

Table 3 Description of objectives for JITEE.

Description	Definition
Understand	Need to learn as a knowledge
Apply with assistance	Apply the knowledge and partly solve a problem under the guidance of the leader
Understand and apply	Understand the leader's policy and apply the knowledge to solve a problem
Understand and utilize	Combine a related set of knowledge and apply them to solve a problem

The syllabus of each examination category is a set of topics. Each topic is classified using a two-level hierarchy and is composed of an objective and a content. The objective briefly explains the scope and the depth of the topic which an examinee is expected to achieve. The scope and the depth are described in a standard form as summarized in **Table 3**. The content describes the detailed topics along with examples of technical terms and an application of knowledge in a concrete manner.

5. Common Analysis Plan of J07 and JITEE

ICTBOK has a three-level hierarchical structure composed of categories, fields and areas. We shall assign the requirement level of each area through the analysis. In order to do this, we define requirement levels 0 to 5 as shown in **Table 4**. The reader should note that the definition of the levels is slightly different from the levels [*1] defined in Table 2 in order to describe the level more precisely especially for college level education. Basically, the levels are defined according to the Bloom's taxonomy. The difference between levels 0 and 1 for skill is that some education or training is required to achieve level 1. Level 2 is the level to explain the knowledge area or to execute the knowledge with detailed instructions. Level 3 of the skill is the level to execute the area with simplified instructions. Typically extensive training at a laboratory is required to achi eve level 3 while learning or exercise at a 15-week course is required to achieve level 2. Education to earn a master degree is usually expected to achieve level 4. A student or ICT professional is required to combine related knowledge to achieve knowledge level 4. The level also implies that the student

[*1] Hereafter, we describe the levels defined in Table 2 as CCSF levels.

Table 4 Achievement and requirement levels.

Level	Knowledge	Skill
0	Do not know	Cannot execute
1	Understand or know	
2	Explain	Execute with detailed instructions
3	Join a discussion using the knowledge	Execute with simple instructions
4	Utilize the knowledge for problem solving	Proficient in the skill
5	*Unused*	Can teach others

Table 5 Examples of verbs to describe learning objectives.

Knowledge	Skill
understand, explain, describe, state, illustrate by example, compare, differentiate, discuss	compute, perform, use, solve, develop, design, implement, test, debug, create, apply, choose, analyze

or ICT professional can teach the knowledge to others so that we do not define knowledge level 5.

We also estimate the weight of each area representing the degree of importance of the area through the requirement analysis.

The analysis of J07 is carried out in order to estimate the requirement level and the weight of each ICTBOK area for each domain of J07.

Among the domains of J07, CS, CE and IT have the same structure. Thus we shall explain the common analysis plan for these three domains. The remaining two domains, SE and IS, will be discussed in Section 6.

Assuming the above BOK structure explained in Section 2, we first make the correspondence between the core units and the areas of ICTBOK. If a unit corresponds to a single area, the core coverage time of the unit is assigned to the area. In case that multiple areas correspond to a unit, the core time is proportionally distributed among the areas considering the learning objectives and topics of the unit.

When we have built the correspondence, the weight of each area is computed by the sum of the core times of the area. The weight of each category and field can be computed similarly.

The requirement level of each area is basically determined from the learning objectives of the corresponding core units. The learning objectives are described using various verbs summarized in **Table 5**. Knowledge and skill requirements can be evaluated by these verbs. However, the requirement level is set to zero, if the assigned core time is zero since the teaching of the area is not guaranteed. The requirement level is set to one if the assigned core time is an hour or less, since it is expected to be difficult to teach an area within an hour so that students can explain the area.

After estimating the requirement level and weight of each area, we summarize the analysis result by summing the weight for each field to overview the distribution of weight for 23 fields of ICTBOK. We also count the number of areas with a requirement level greater than 1 and the average requirement level among such areas. The information represents the overall profile of a J07 domain.

The analysis of JITEE is carried out essentially in the same process of J07 requirement analysis. However each syllabus does not contain the notion of core time so that we shall use the number of topics instead to estimate the weight of each ICTBOK area [*2]. The knowledge and skill level of each area is estimated based on the assigned topics and the corresponding description of the objectives as explained in Table 3.

6. Requirement Analysis of J07 Domains

6.1 Common Analysis Result

Figure 2 illustrates the distributions of the importance levels (weights) of the fields of the J07 domains. The weights of the fields are normalized so that the sum of the weights is equal to 100% for each domain.

Table 6 represents the numbers of covered ICTBOK areas for each J07 domain and the average requirement level for knowledge and skill. This is useful to visualize the scope and the depth of each domain in a quantitative manner. No area has a requirement level 3 or more because level 3 is typically achieved by extensive training through a graduation research project which is outside of the scope of J07. Thus the average part of the requirements is represented by the number of level 2 areas.

The readers can find a list of ICTBOK areas for each J07 domain in Appendix A.2. The areas are sorted in the descending order of weight (importance level) and the estimated requirement levels are associated for knowledge and skill.

6.2 Computer Science (CS)

Analysis of J07-CS is carried out as explained in Section 5. The correspondence between ICTBOK areas and J07-CSBOK units has been reviewed for correctness by a J07-CS committee member. In Japan, the majority of ICT departments teach computer science, which focus on the theory and modeling issues. However, CS is not only a theoretical domain. CS also focuses on computer programming and software engineering as can be seen from Fig. 2. This may be contrary to the intuition for the readers. Such a quantitative analysis becomes possible using our approach.

The number of covered ICTBOK areas and the average requirement level are at the average among the five disciplines.

6.3 Computer Engineering (CE)

Analysis of J07-CE is carried out as described in Section 5. CE is the second largest community of ICT departments in Japan. J07-CE focuses on hardware, architecture and embedded software development. Compared with CE2004 [2], the software issue is more emphasized in J07-CE. This can be observed in Fig. 2 by the weights assigned to software engineering, computer programming, and database.

6.4 Software Engineering (SE)

Taking the structure of J07-SE, explained in Section 4, into consideration, we assign each week of the J07-SE courses to ICTBOK areas. The weight of the area is defined by the number of courses. For example, the weight of an area becomes 2/13 if two weeks of a 13-week course correspond to the area. The

[*2] If a JITEE syllabus introduces the notion of weight or core time for each topic, a more precise requirement analysis will become possible.

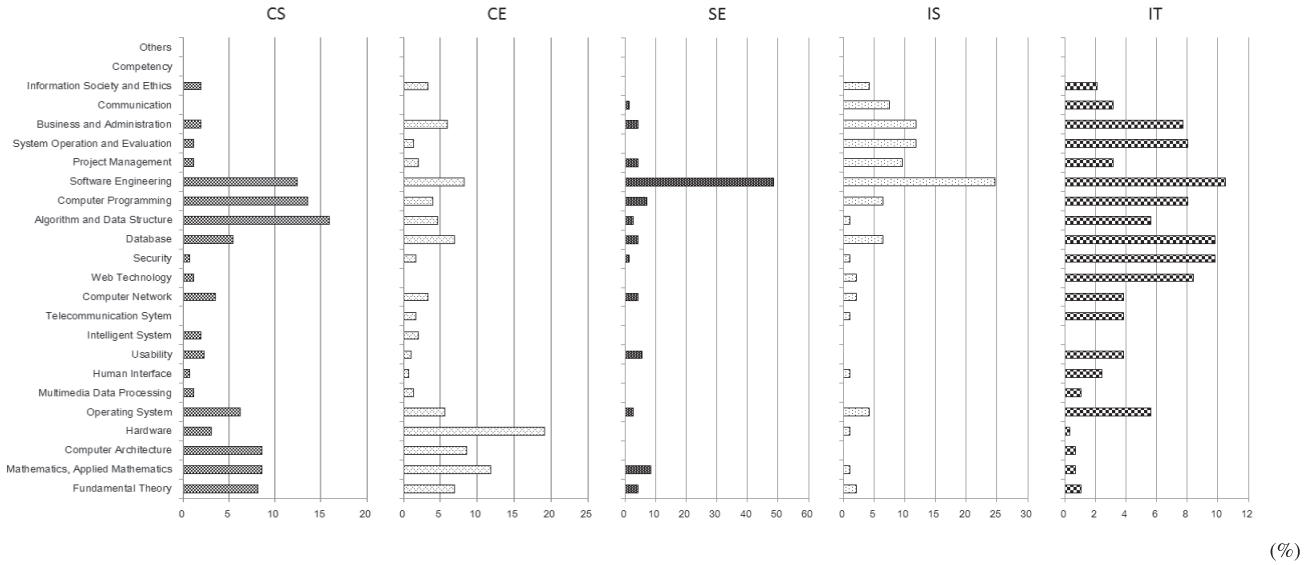


Fig. 2 Importance level distribution of J07 domains.

Table 6 Number of corresponding ICTBOK areas and average requirement level of J07 domains.

	Knowledge					Skill				
	CS	CE	SE	IS	IT	CS	CE	SE	IS	IT
# of ICTBOK areas	50	61	40	73	69	27	22	20	22	69
Average requirement level	1.86	1.82	1.55	1.32	1.84	1.89	1.73	1.45	2.09	1.41

knowledge and skill requirement levels are estimated according to the following criteria.

- Knowledge and skill requirement levels are zero if the area has no weight.
- The knowledge requirement level is one if the weight of the area is less than or equal to 2/13; two if the weight is more than 2/13.
- The skill requirement level is computed in a similar way as in the case of a knowledge requirement level. The only difference is that the weight is defined by the number of exercises instead of lectures.

J07-SE strongly focuses on the software engineering field as illustrated in Fig. 2. This is because J07-SE intends to develop a highly skilled software developer. However the average skill requirement level (1.45) is at the lowest level among the five domains.

6.5 Information Systems (IS)

The analysis of J07-IS is carried out using the core LUs. We first assign every LU to an ICTBOK area. If there are more than one areas corresponding to an LU, the number of LU is proportionally assigned to each area. The weight of each area is computed by the number of core LUs corresponding to the area.

Requirement levels are determined using the following rules.

- Knowledge and skill requirement levels are zero if there is no core LU corresponding to the area.
- The knowledge requirement level of an area is one if the levels of corresponding core LUs are either 0 or 1, two if the level of a corresponding core LUs is 2 or above.
- The skill requirement level of an area is one if the levels of corresponding core LUs are 3, two if the level of a corresponding core LU is either 4 or 5.

Information systems focus on business administration, system operation and project management as well as software engineering. This is because that J07-IS ultimately aims at developing chief information officer (CIO). The average requirement knowledge level is the lowest among the five J07 domains. But the number of covered ICTBOK areas for a knowledge is the largest. This implies that J07-IS requires graduates to have a wide range of knowledge as a CIO candidate. Although the number of ICTBOK areas for a skill is at the lowest level, the skill requirement level is the highest.

6.6 Information Technology (IT)

Analysis of J07-IT is carried out as described in Section 5. J07-IT is partly similar to J07-IS, but J07-IT focuses on developing a computer administrator. This can be observed from Fig. 2 by the weights assigned to the fields such as database, security and web technology. Compared with other J07 domains, the weight of each field is more widely distributed. The number of covered areas for a skill is the largest among the five domains. This implies that J07-IT requires practical knowledge and skill as computer administrators.

7. Requirement Analysis of JITEE Examination Categories

Before analyzing JITEE examination categories, we asked for a review to a senior staff of IPA Skill Standard Center on correspondence between ICTBOK and JITEE syllabuses. Thus the succeeding analysis result can be considered valid.

Figure 3 illustrates the distributions of the importance levels (weights) of the fields of JITEE examination categories. The weights of the fields are normalized so that the sum of the weights is equal to 100% as in the case of J07 analysis.

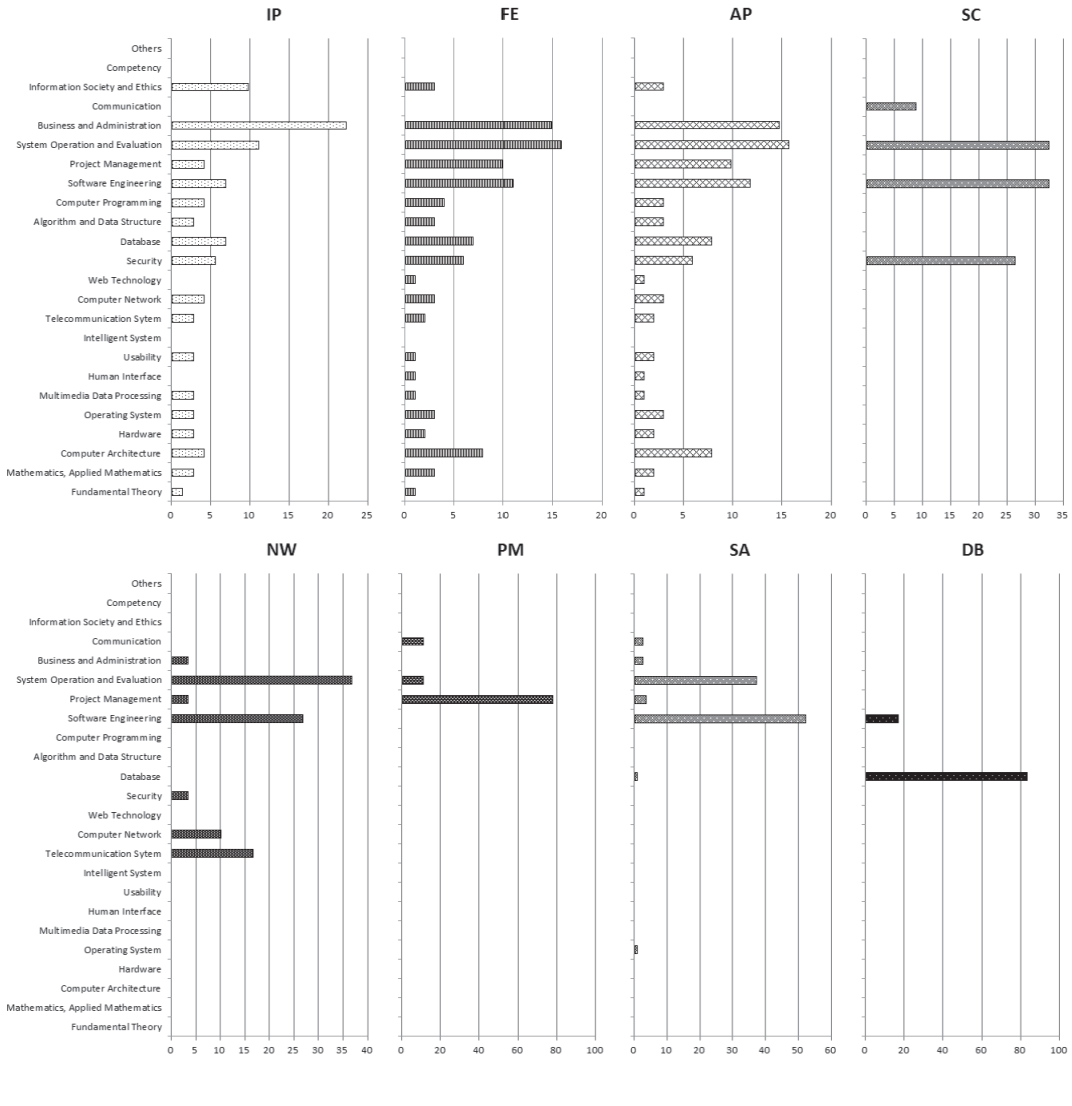


Fig. 3 Importance level distribution of JITEE examination categories.

Table 7 Number of corresponding ICTBOK areas and average requirement level of JITEE examination categories.

Knowledge

	IP	FE	AP	SC	NW	PM	SA	DB
# of ICTBOK areas	57	82	94	10	12	10	21	4
Average requirement level	1.04	2.00	3.83	4.00	4.00	4.00	4.00	4.00

Skill

	IP	FE	AP	SC	NW	PM	SA	DB
# of ICTBOK areas	2	59	94	10	12	10	21	4
Average requirement level	2.00	2.09	3.83	5.00	5.00	5.00	5.00	4.00

Table 7 represents the numbers of covered ICTBOK areas for each JITEE examination category and the average requirement levels for knowledge and skill.

We can find the followings by observing Fig. 3 and Table 7.

- IP, FE and AP require a wide range of areas, while advanced level examinations require specific areas. Examinees must have knowledge and skill required for AP in order to pass the advanced examination. In this sense, an advanced examination syllabus only describes the specific knowledge and skill of the examination categories.
- IP basically requires knowledge of level 1. It requires skill only at two areas. Thus we can correspond a combination of knowledge level 1 and skill level 0 to the level 1 of common career/skill framework (CCSF) defined in Table 2.
- In case of IP, more than 20% of the weight is assigned to non-ICT fields (Business and administration). This is because that expected examinee of IP is a new working member of the society whose major may not be IT.
- Importance level distributions of FE and AP are similar. Both FE and AP focus more on IT fields than IP. The major difference between FE and AP is the average requirement levels of knowledge and skill. FE mainly requires level 2

Table 8 Similarity among JITEE examination categories.

	IP	FE	AP	SC	NW	PM	SA
FE	*0.8121*	1					
AP	*0.8063*	*0.9953*	1				
SC	0.2712	0.5519	0.5659	1			
NW	0.3495	0.6182	0.6276	*0.7669*	1		
PM	0.0172	0.3119	0.3033	0.0108	0.0720	1	
SA	0.3091	0.6103	0.6333	*0.8268*	*0.8544*	0.0644	1
DB	0.1439	0.1875	0.2347	0.0300	0.0074	−0.0659	0.1048

Table 9 Similarity among J07 domains.

	CS	CE	SE	IS
CE	0.4515	1		
SE	0.4949	0.2533	1	
IS	0.2515	0.1090	*0.7726*	1
IT	0.2599	−0.0868	0.4259	0.6087

Table 10 Similarity between J07 domain and JITEE category.

	CS	CE	SE	IS	IT
IP	0.0267	0.1694	0.1640	0.5325	0.4688
FE	0.1389	0.1656	0.3361	*0.7117*	0.5679
AP	0.1242	0.1546	0.3655	*0.7284*	0.5856
SC	0.0400	−0.0588	0.5172	0.6278	0.5610
NW	0.0061	−0.0567	0.4484	0.6313	0.4309
PM	−0.1815	−0.1488	−0.0187	0.2596	−0.0355
SA	0.2162	0.0732	*0.7517*	*0.8349*	0.4690
DB	0.1320	0.1664	0.1933	0.2335	0.4115

which corresponds to CCSF level 2, while AP mainly requires level 4 corresponding to CCSF level 3.

- Advanced level examinations require knowledge level 4 and skill level 5. These levels correspond to CCSF level 4.

The readers can find a list of ICTBOK areas for each examination category of JITEE in Appendix A.3. The areas are sorted in the descending order of importance level. The estimated requirement levels are associated for knowledge and skill.

8. Comparison of J07 Domains and JITEE Examination Categories

8.1 Similarity Analysis Based on Importance Level

Characteristics of a J07 domain or a JITEE examination category can be represented by a 23 dimensional vector, i.e., importance levels (weights) of the fields. Then we can evaluate the similarity among them by computing the correlation coefficient of the corresponding vectors. They are represented separately in **Table 8**, **Table 9** and **Table 10**. A pair is represented using italic font if the correlation coefficient is larger than 0.7.

The readers can easily observe that SE and IS are similar within J07 domains. IP, FE and AP are similar within JITEE. SC, NW and SA are also similar. There is a similarity between IS and FE, AP and SA in JITEE so that a mismatch is rather small between these combinations. This implies that there is a common policy or direction between the similar pair. Such a comparison becomes possible by using our approach since they are now described using the same terminology.

Table 11 Overall satisfaction ratio of J07 domains against JITEE examination categories (level 1 to 3)

J07	Satisfaction Ratio (%)		
Domain	IP	FE	AP
CS	41.11	31.56	14.72
CE	58.89	38.55	18.30
SE	45.56	31.28	14.06
IS	76.67	47.49	23.21
IT	62.22	55.31	28.91

8.2 Comparison Based on Requirement Level Satisfaction Ratio

CCSF level 2 corresponds to the level of college graduates willing to be IT engineers as explained in Table 2. CCSF levels 1 and 3 correspond to the level of non-ICT college graduate and ICT graduate student. Thus it is valuable to compare J07 domains and JITEE-IP, FE, AP examinations.

Table 11 represents the overall satisfaction ratio of each J07 domain against JITEE examination category. The satisfaction ratio is defined by the following formula.

$$\frac{\sum w_{JITEE} \times min(r, r_{JITEE})}{\sum w_{JITEE} \times r_{JITEE}}$$

In the above formula, r is the requirement level of a J07 domain at each area. w_{JITEE} and r_{JITEE} are the importance and the requirement levels of a JITEE examination at the same area. The weighted sums of the knowledge and skill requirement levels are 202 and 156 respectively in case of the FE examination. Thus the weight of the skill requirement is 77% of the knowledge requirement.

It can be observed from Table 11 that the requirement of J07 domains is generally less than the requirement of the FE examination. One reason of this is that JITEE syllabus is seldom referenced during J07 curriculum development process. In this sense, relationship analysis is important for future development of computing curriculum standard and ICT examination. Another reason is that J07 only defines one-year technical education for ICT graduates and does not include education through a graduation research project. The requirement gap should be considered to design a concrete curriculum at each university. Although it is not mandatory for a university to achieve FE level, the FE level can be considered as a society's expectation provided by the Japanese government. It is also valuable for a student to study for JITEE examination as career development. Thus there is a reason or social responsibility for an ICT university to refer the JITEE-FE requirement. Simila rly, JITEE-AP (CCSF level 3) can be considered as a society's expectation for a graduate student having majored in ICT.

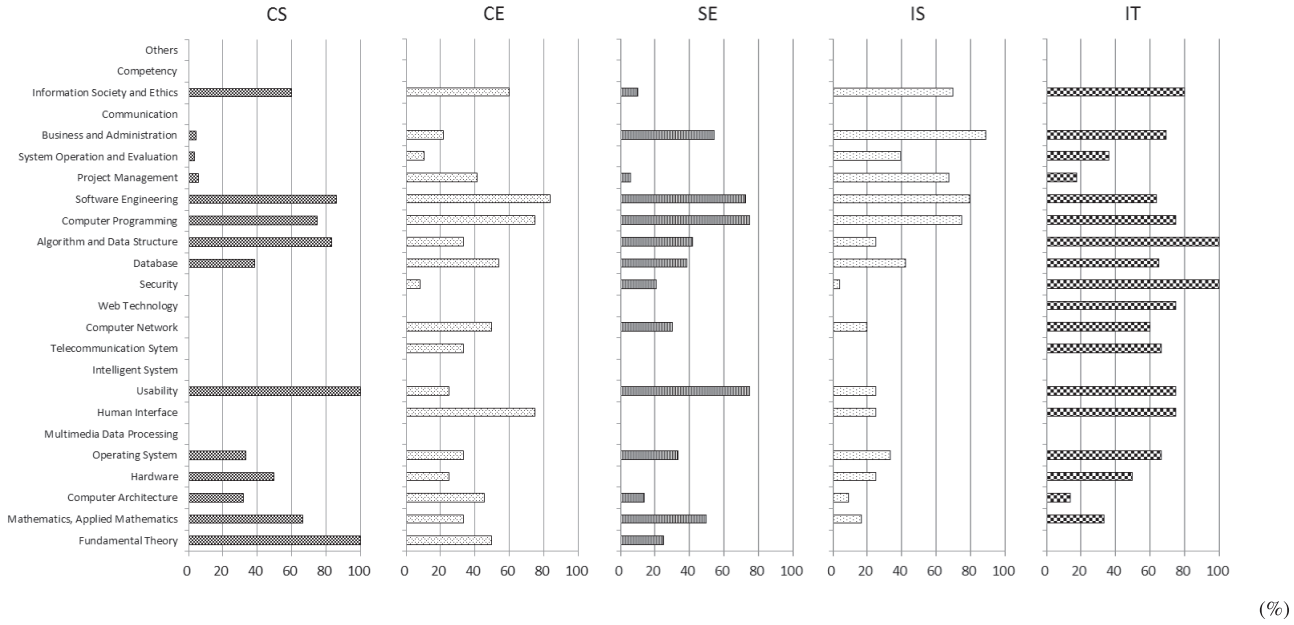


Fig. 4 Satisfaction ratio of J07 domains against JITEE-FE examination at each field.

Figure 4 illustrates the satisfaction ratio of each ICTBOK field of each J07 domain against the JITEE-FE examination. The satisfaction ratio is calculated for the areas belonging to each field. A quantitative comparison of the J07 domains and the FE examination becomes possible by observing Fig. 4. Particularly strong and weak fields of a J07 domain are visualized from the viewpoint of the FE examination.

Note that the weights of the following three fields are zero in the case of JITEE-FE examination so that the satisfaction ratio of the fields cannot be defined.

- Intelligent System
- Communication
- Competency

Considering the fact that the importance of "Communication" and "Competency" are high at our requirement level survey project from the industry [7], we can say that the FE examination also has some weak points as explained above. The readers can refer to Fig. 3 for the entire distribution of the weights of the FE examination. We can observe from Fig. 4 that the maximum satisfaction ratio is greater than 60% for most of the fields. The exceptions are the following three fields.

- Computer Architecture
- Multimedia Data Processing
- System Operation and Evaluation

These three fields are the common candidate for future improvement of the J07 domains. From the other viewpoint, universities can develop their own curriculum by integrating the desired portion of J07 domains.

We do not compare J07 domains against JITEE advanced level examinations in this paper. There are some departments or laboratories that teach knowledge and skill of the advanced level examination. Such education often contains a practical training, such as PBL or internship program, at a real world environment. Such effort is valuable to prepare students to quickly achieve CCSF level 4 for which a 5-year working experience is typically required. It is usually difficult to achieve CCSF level 4 only by college education.

9. Conclusion

In this paper, J07 domains and JITEE examination categories are analyzed using ICTBOK as a common vocabulary. As a result, the relationship among J07 domains and JITEE examination categories is clarified. Such a clarification of the relationship is a first step to build an effective education system to develop a high level ICT professional with the cooperation of academia and industry.

We also collect requirement data from the industry [7] and achievement data from the academia [8] respectively. Since the requirement and achievement data are collected using ICTBOK, the relationship between them can be analyzed quantitatively. Furthermore it is also possible to compare such data with the analysis result obtained in this paper. We have developed a Web-based system named "cresie" in order to collect requirement and achievement data [9]. The comparison function will be added to the system in the near future.

The authors believe that a common terminology and a quantitative analysis of education outcome is necessary to promote the cooperation between the academia and the industry. Although it is not necessary for an education program to teach the entire requirement, an educational institution should understand the background or reason of the requirement and try to improve their education program. It is also true that the industry should understand the effort of the academia and provide a reasonable requirement. Our work is a start point of such effort.

It is often said that there is a mismatch between the industry's requirement and the university's achievement in ICT education. Our research focuses on this point and aims at clarifying the mismatch. In this paper, we analyze the J07 curriculum standard to compare requirements of J07 domains with the industry's requirement. The relationship among J07 domains is clarified using the

importance and requirement levels. It is observed that the J07 domains should also focus on competences so that the graduates of the domain can achieve competency requirements.

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Appendix

A.1 ICTBOK

Field	Area
Fundamental Theory (FND)	Mathematical Logic
	Language Theory, Automaton, Theory of Computation
	Computational Complexity Theory
	Numerical Analysis
	Simulation
	Digital Representation of Information
	Representation of Numeric and Character Data
Mathematics, Applied Mathematics (MATH)	Calculus
	Linear Algebra
	Discrete Mathematics
	Probability Theory and Statistics
	Optimization
Computer Architecture (ARCH)	General Purpose Processor
	Special Purpose Processor
	Architecture Description Language
	Memory Architecture, Memory Device
	Hardware Interface
	Instrumental Engineering
	Control Engineering
	Embedded Systems
	High Performance Computing
Hardware (HW)	Electric Circuit
	Electronic Circuit
	Digital Signal Processing
	I/O
	VLSI Description Language
	Logic Circuit Design
	VLSI Design
Operating System (OS)	Basic Concepts
	Organization and Evaluation of Operating System
	Application of Operating System
	Implementation of Operating System
	Specific OS
Multimedia Data Processing (MMDP)	Compression of Multimedia Data
	Multimedia Data Management
	Computer Graphics
	Image Processing and Recognition
	Sound Processing and Recognition
	Design and Development of Digital Contents
	Evaluation of Digital Contents
	Application of Multimedia Data Processing
Human Interface (HUI)	Ergonomics
	Cognitive Engineering
	Interaction and HMI
Usability	Usability Design
	Usability Evaluation
Intelligent System (INTL)	Artificial Intelligence
	Knowledge Processing
	Machine Learning
	Natural Language Processing
	Pattern Recognition
	Robotics
Telecommunication System (Telecomm)	Fundamental of Communication Engineering
	Communication Technology
	Wireless Communication
	Wired Communication
	Mobile Communication
	QoS Control
	Network Device
	Law, Social System, Standardization
	Development, Management and Operation
Computer Network (NET)	Network Architecture
	Implementation of Computer Network
	Network Management
	Application Management
	Distributed System
	Network Programming
Web Technology (WEB)	World Wide Web
	Web Page Description Language
	Protocol, Server
	Web Programming
	Search Engine Optimization
	Weblog
	Web Software
	Security
Security	Cryptography
	Network Security
	Authentification
	Copyright Management and Protection
	Security Management
	Security and Society

Field	Area
Database (DB)	Database System Concepts
	Database Language
	DBMS
	Transaction Management
	Logical Database Design
	Physical Database Design
	System Development, Management, Operation
	Specific DBMS
	Information Retrieval
	Data Mining
Algorithm and Data Structure (ALGO)	Data Structure
	Basic Algorithms
	Encryption Algorithm
	Computation Complexity
	Algorithm Design
Computer Programming (PRG)	Foundation of Programming Language
	Foundation of Programming
	Language Processor
	Object Oriented Programming
	Specific Programming Language
Software Engineering (SWE)	Requirement Analysis
	Structured Analysis and Design
	Data Modeling
	Data Description Language
	Object Oriented Analysis and Design
	Software Architecture
	Metrics and Measurement
	Software Reuse
	Software Process
	Software Development Environment
	Validation and Testing
Project Management (PM)	Fundamental Concepts
	Time Management
	Cost Management
	Quality Management
	Acquisition Management
	Management on Others
System Operation and Evaluation (OPR)	Fundamental Concepts
	Planning
	Operation
	Evaluation
	Maintenance
	Evolution
	Specific Information System
	Business Process Revolution
Business and Administration (Business)	Law and Ethics
	Business Strategy and Organization
	Human Resource Management
	Environment Analysis
	Accounting
	Marketing
	Decision Making
	Operation
Communication (COMM)	Fundamental Concepts
	Reading, Writing, Presentation
	English
	Practical Skill
	Negotiation
Information Society and Ethics (SOC)	Computer Literacy
	Intellectual Property
	Information Ethics
	Law on IT
Competency	Ability to Act Positively
	Ability to Influence People
	Ability to Set Goal and to Act
	Ability to Analyze Current Status
	Planning Ability
	Creativity
	Ability to Express One's Opinion
	Ability to Listen Carefully
	Flexibility
	Ability to Understand Circumstances
	Ability to Keep Rule or Promise
	Ability to Manage Stress

A.2 Requirement Level Analysis of J07 Domains

We shall illustrate the detailed result of the requirement level analysis in this appendix. The areas are sorted in the order of the importance level (weight) and are illustrated with knowledge and skill requirement levels. The following is the list of abbreviations.

- Req. Level: Requirement level
- KLG: Knowledge
- SKL: Skill
- %: Importance value (%)
- ACC %: Accumulated importance value (%)
- Rank: Ranking of the importance value

The areas are listed until the accumulated importance value exceeds 70% so that most of the areas having weight appear in the list.

A.2.1 Computer Science (CS)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
MATH	Discrete Mathematics	2	2	7.00	7.00	1
PRG	Foundation of Programming Language	2	2	7.00	14.01	1
ALGO	Algorithm Design	2	2	5.84	19.84	3
ALGO	Data Structure	2	2	5.45	25.29	4
ARCH	General Purpose Processor	2		5.06	30.35	5
OS	Basic Concepts	2		4.28	34.63	6
FND	Language Theory, Automaton, Theory of Computation	2	2	3.89	38.52	7
NET	Network Architecture	2	2	3.50	42.02	8
DB	Database System Concepts	2	2	3.11	45.14	9
ALGO	Basic Algorithms	2		3.11	48.25	9
PRG	Foundation of Programming	2	2	2.72	50.97	11
SWE	Object Oriented Analysis and Design	2	2	2.72	53.70	11
FND	Mathematical Logic	2	2	2.33	56.03	13

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
ARCH	Memory Architecture, Memory Device	2		2.33	58.37	13
Hardware	Logic Circuit Design	2	2	2.33	60.70	13
PRG	Object Oriented Programming	2	2	2.33	63.04	13
SWE	Software Reuse	2		2.33	65.37	13
SWE	Requirement Analysis	2	2	1.95	67.32	18
Business	Decision Making	2		1.95	69.26	18
MATH	Probability Theory and Statistics	2	2	1.56	70.82	20
OS	Implementation of Operating System	2		1.56	72.37	20
Usability	Usability Design	2	2	1.56	73.93	20
ALGO	Computation Complexity	2		1.56	75.49	20
PRG	Language Processor	2	2	1.56	77.04	20
SWE	Validation and Testing	2	2	1.56	78.60	20

A.2.2 Computer Engineering (CE)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
HW	Electric Circuit	2		7.26	7.26	1
MATH	Probability Theory and Statistics	2		6.60	13.86	2
MATH	Discrete Mathematics	2		5.28	19.14	3
HW	Logic Circuit Design	2	2	5.28	24.42	3
FND	Digital Representation of Information	2	2	4.95	29.37	5
ARCH	General Purpose Processor	2		4.95	34.32	5
HW	VLSI Design	2	2	4.95	39.27	5
Business	Decision Making	2		3.96	43.23	8
OS	Basic Concepts	2		3.30	46.53	9
ALGO	Algorithm Design			2.64	49.17	10
SOC	Information Ethics	2		2.31	51.49	11
ARCH	Memory Architecture, Memory Device	2		1.98	53.47	12
OS	Implementation of Operating System	2		1.98	55.45	12
INTL	Knowledge Processing	2		1.98	57.43	12
DB	DBMS	2		1.98	59.41	12
PRG	Foundation of Programming Language	2	2	1.98	61.39	12
SWE	Software Development Environment	2	2	1.98	63.37	12
NET	Network Architecture	2		1.65	65.02	18
DB	Logical Database Design	2	2	1.65	66.67	18
SWE	Validation and Testing	2	2	1.65	68.32	18

A.2.3 Software Engineering (SE)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
SWE	Validation and Testing	2	2	11.43	11.43	1
SWE	Software Architecture	2	2	10.00	21.43	2
SWE	Requirement Analysis	2	2	8.57	30.00	3
Usability	Usability Design	2	1	5.71	35.71	4
SWE	Software Process	2		5.71	41.43	4
MATH	Discrete Mathematics	2		4.29	45.71	6
PRG	Foundation of Programming Language	2	2	4.29	50.00	6
PM	Fundamental Concepts	2		4.29	54.29	6
FND	Mathematical Logic	2	1	2.86	57.14	9
MATH	Linear Algebra	2		2.86	60.00	9
OS	Basic Concepts	2	2	2.86	62.86	9
NET	Network Architecture	2		2.86	65.71	9
ALGO	Basic Algorithms	2	2	2.86	68.57	9
PRG	Foundation of Programming	2	2	2.86	71.43	9
SWE	Data Modeling	2		2.86	74.29	9
SWE	Object Oriented Analysis and Design	2		2.86	77.14	9
SWE	Software Reuse	2		2.86	80.00	9
Business	Operation	2	2	2.86	82.86	9
FND	Language Theory, Automaton, Theory of Computation	2	1	1.43	84.29	19
MATH	Probability Theory and Statistics	2	2	1.43	85.71	19
NET	Implementation of Computer Network	2	1	1.43	87.14	19
Security	Network Security	1		1.43	88.57	19
DB	Database System Concepts	1	1	1.43	90.00	19

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
DB	Logical Database Design	1	1	1.43	91.43	19
DB	Physical Database Design	1	1	1.43	92.86	19
SWE	Structured Analysis and Design	1	1	1.43	94.29	19
SWE	Metrics and Measurement	1		1.43	95.71	19
SWE	Software Development Environment	1		1.43	97.14	19
Business	Decision Making	1		1.43	98.57	19
COMM	Practical Skill	2	1	1.43	100.00	19

A.2.4 Information Systems (IS)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
OPR	Fundamental Concepts	2		7.53	7.53	1
COMM	Practical Skill	2	2	6.45	13.98	2
SWE	Software Process	2	2	5.38	19.35	3
Business	Operation	2	2	5.38	24.73	3
SWE	Metrics and Measurement	2	2	4.30	29.03	5
PM	Fundamental Concepts	2	2	4.30	33.33	5
SWE	Structured Analysis and Design	2	3	3.23	36.56	7
SWE	Validation and Testing	2		3.23	39.78	7
PM	Management on Others	2	2	3.23	43.01	7
Business	Decision Making	2	2	3.23	46.24	7
OS	Basic Concepts	2		2.15	48.39	11
OS	Application of Operating System	2	3	2.15	50.54	11
DB	Database Language	2	2	2.15	52.69	11
DB	Logical Database Design	2	2	2.15	54.84	11
PRG	Foundation of Programming Language	2	2	2.15	56.99	11
PRG	Foundation of Programming	2	2	2.15	59.14	11
PRG	Object Oriented Programming	2	2	2.15	61.29	11
SWE	Requirement Analysis	2	2	2.15	63.44	11
SWE	Object Oriented Analysis and Design	2	2	2.15	65.59	11
SWE	Software Development Environment	2	2	2.15	67.74	11
OPR	Planning	2	2	2.15	69.89	11
Business	Business Strategy and Organization	2		2.15	72.04	11
SOC	Computer Literacy	2		2.15	74.19	11

A.2.5 Information Technology (IT)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
OPR	Fundamental Concepts	2	1	5.26	5.26	1
Business	Decision Making	2	2	5.26	10.53	1
WEB	Web Programming	2	2	3.86	14.39	3
OS	Organization and Evaluation of Operating System	2	2	3.51	17.89	4
Security	Security Management	2	2	3.51	21.40	4
DB	Database Language	2	2	3.16	24.56	6
PRG	Foundation of Programming	2	2	3.16	27.72	6
PRG	Object Oriented Programming	2	2	3.16	30.88	6
Usability	Usability Design	2	1	2.81	33.68	9
Security	Network Security	2	2	2.81	36.49	9
DB	Logical Database Design	2	2	2.46	38.95	11
SWE	Software Reuse	2	2	2.46	41.40	11
OS	Basic Concepts	2	2	2.11	43.51	13
SWE	Requirement Analysis	2	2	2.11	45.61	13
SWE	Data Modeling	2	2	2.11	47.72	13
COMM	Practical Skill	2	2	2.11	49.82	13
ALGO	Data Structure	2	2	1.75	51.58	17
ALGO	Basic Algorithms	2	2	1.75	53.33	17
PRG	Foundation of Programming Language	2	2	1.75	55.09	17
SWE	Data Description Language	2	2	1.75	56.84	17
PM	Fundamental Concepts	2	2	1.75	58.60	17
Business	Business Strategy and Organization	2	1	1.75	60.35	17
NET	Network Architecture	2	1	1.40	61.75	23
WEB	Web Page Description Language	2	2	1.40	63.16	23

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Security	Cryptography	2	1	1.40	64.56	23
DB	DBMS	2	1	1.40	65.96	23
PM	Acquisition Management	2	2	1.40	67.37	23
OPR	Specific Information System	2	1	1.40	68.77	23
SOC	Information Ethics	2	1	1.40	70.18	23

A.3 Requirement Analysis of JITEE Examination Categories

The abbreviations of the table are the same as in Appendix A.2. The areas are listed until the accumulated importance value becomes 100% so that all areas having weight appear in the list.

A.3.1 Information Technology Passport Examination (IP)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Business	Business Strategy and Organization	1		5.56	5.56	1
SOC	Computer Literacy	2	2	5.56	11.11	1
Business	Decision Making	1		4.17	15.28	3
Business	Operation	1		4.17	19.44	3
HW	I/O	1		2.78	22.22	5
OS	Basic Concepts	1		2.78	25.00	5
Usability	Usability Design	1		2.78	27.78	5
SWE	Requirement Analysis	2	2	2.78	30.56	5
SWE	Software Process	1		2.78	33.33	5
PM	Fundamental Concepts	1		2.78	36.11	5
OPR	Operation	1		2.78	38.89	5
OPR	Evaluation	1		2.78	41.67	5
OPR	Specific Information System	1		2.78	44.44	5
Business	Law and Ethics	1		2.78	47.22	5
Business	Marketing	1		2.78	50.00	5
SOC	Information Ethics	1		2.78	52.78	5
FND	Representation of Numeric and Character Data	1		1.39	54.17	17
MATH	Discrete Mathematics	1		1.39	55.56	17
MATH	Probability Theory and Statistics	1		1.39	56.94	17
ARCH	General Purpose Processor	1		1.39	58.33	17
ARCH	Memory Architecture, Memory Device	1		1.39	59.72	17
ARCH	Embedded Systems	1		1.39	61.11	17
MM-DP	Compression of Multimedia Data	1		1.39	62.50	17
MM-DP	Application of Multimedia Data Processing	1		1.39	63.89	17
Telecomm	Network Device	1		1.39	65.28	17
Telecomm	Law, Social System, Standardization	1		1.39	66.67	17
NET	Network Architecture	1		1.39	68.06	17
NET	Implementation of Computer Network	1		1.39	69.44	17
NET	Distributed System	1		1.39	70.83	17
Security	Cryptography	1		1.39	72.22	17
Security	Network Security	1		1.39	73.61	17
Security	Authentification	1		1.39	75.00	17
Security	Security Management	1		1.39	76.39	17
DB	Database System Concepts	1		1.39	77.78	17
DB	Database Language	1		1.39	79.17	17
DB	DBMS	1		1.39	80.56	17
DB	Transaction Management	1		1.39	81.94	17
DB	Logical Database Design	1		1.39	83.33	17
ALGO	Data Structure	1		1.39	84.72	17
ALGO	Basic Algorithms	1		1.39	86.11	17
PRG	Foundation of Programming Language	1		1.39	87.50	17
PRG	Foundation of Programming	1		1.39	88.89	17
PRG	Specific Programming Language	1		1.39	90.28	17
SWE	Metrics and Measurement	1		1.39	91.67	17
PM	Acquisition Management	1		1.39	93.06	17
OPR	Fundamental Concepts	1		1.39	94.44	17
OPR	Planning	1		1.39	95.83	17
Business	Human Resource Management	1		1.39	97.22	17
Business	Accounting	1		1.39	98.61	17
SOC	Intellectual Property	1		1.39	100.00	17

A.3.2 Fundamental Information Technology Engineer Examination (FE)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Business	Operation	2	2	5.94	5.94	1
OPR	Operation	2	2	4.95	10.89	2
Business	Business Strategy and Organization	2		4.95	15.84	2
Security	Security Management	2	2	3.96	19.80	4
PM	Management on Others	2	2	3.96	23.76	4
OPR	Planning	2	2	3.96	27.72	4
SWE	Requirement Analysis	2	2	2.97	30.69	7
SWE	Validation and Testing	2	2	2.97	33.66	7
OPR	Evaluation	2	2	2.97	36.63	7
OPR	Specific Information System	2		2.97	39.60	7
ARCH	Embedded Systems	2		1.98	41.58	11
HW	I/O	2	2	1.98	43.56	11
PRG	Foundation of Programming	2	2	1.98	45.54	11
SWE	Software Process	2	2	1.98	47.52	11
SWE	Software Development Environment	2	2	1.98	49.50	11
PM	Acquisition Management	2		1.98	51.49	11
SOC	Intellectual Property	2	2	1.98	53.47	11
FND	Representation of Numeric and Character Data	2	2	0.99	54.46	18
MATH	Discrete Mathematics	2	2	0.99	55.45	18
MATH	Probability Theory and Statistics	2	2	0.99	56.44	18
MATH	Optimization	2	2	0.99	57.43	18
ARCH	General Purpose Processor	2	2	0.99	58.42	18
ARCH	Memory Architecture, Memory Device	2	2	0.99	59.41	18
ARCH	Hardware Interface	2		0.99	60.40	18
ARCH	Instrumental Engineering	2		0.99	61.39	18
ARCH	Control Engineering	2		0.99	62.38	18
ARCH	High Performance Computing	2	2	0.99	63.37	18
OS	Basic Concepts	2	2	0.99	64.36	18
OS	Organization and Evaluation of Operating System	2	2	0.99	65.35	18
OS	Implementation of Operating System	2	2	0.99	66.34	18
MM-DP	Application of Multimedia Data Processing	2		0.99	67.33	18
HUI	Interaction and HMI	2	2	0.99	68.32	18
Usability	Usability Design	2	2	0.99	69.31	18
Telecomm	Communication Technology	2	2	0.99	70.30	18
Telecomm	Law, Social System, Standardization	2		0.99	71.29	18
NET	Implementation of Computer Network	2	2	0.99	72.28	18
NET	Network Management	2		0.99	73.27	18
NET	Distributed System	2	2	0.99	74.26	18
WEB	Web Software	2	2	0.99	75.25	18
Security	Network Security	2	2	0.99	76.24	18
Security	Authentification	2	2	0.99	77.23	18
DB	Database System Concepts	2	2	0.99	78.22	18
DB	Database Language	2	2	0.99	79.21	18
DB	DBMS	2	2	0.99	80.20	18
DB	Transaction Management	2	2	0.99	81.19	18
DB	Logical Database Design	2	2	0.99	82.18	18
DB	Physical Database Design	2	2	0.99	83.17	18
DB	Specific DBMS	2		0.99	84.16	18
ALGO	Data Structure	2	2	0.99	85.15	18
ALGO	Basic Algorithms	2	2	0.99	86.14	18
ALGO	Algorithm Design	2	2	0.99	87.13	18
PRG	Foundation of Programming Language	2	2	0.99	88.12	18
PRG	Specific Programming Language	2	2	0.99	89.11	18
SWE	Software Reuse	2	2	0.99	90.10	18
PM	Fundamental Concepts	2		0.99	91.09	18
PM	Time Management	2	2	0.99	92.08	18
PM	Cost Management	2	2	0.99	93.07	18
PM	Quality Management	2	2	0.99	94.06	18
OPR	Maintenance	2	2	0.99	95.05	18
Business	Law and Ethics	2		0.99	96.04	18
Business	Accounting	2	2	0.99	97.03	18

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Business	Marketing	2		0.99	98.02	18
Business	Decision Making	2	2	0.99	99.01	18
SOC	Information Ethics	2		0.99	100.00	18

A.3.3 Applied Information Technology Engineer Examination (AP)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Business	Operation	3	3	5.88	5.88	1
OPR	Operation	4	4	4.90	10.78	2
Business	Business Strategy and Organization	3	3	4.90	15.69	2
Security	Security Management	4	4	3.92	19.61	4
PM	Management on Others	3	3	3.92	23.53	4
OPR	Planning	4	4	3.92	27.45	4
SWE	Requirement Analysis	4	4	2.94	30.39	7
SWE	Validation and Testing	4	4	2.94	33.33	7
OPR	Evaluation	4	4	2.94	36.27	7
OPR	Specific Information System	3	3	2.94	39.22	7
ARCH	Memory Architecture, Memory Device	4	4	1.96	41.18	11
ARCH	Embedded Systems	3	3	1.96	43.14	11
HW	I/O	4	4	1.96	45.10	11
PRG	Foundation of Programming	4	4	1.96	47.06	11
SWE	Software Process	4	4	1.96	49.02	11
SWE	Software Development Environment	4	4	1.96	50.98	11
PM	Acquisition Management	3	3	1.96	52.94	11
SOC	Intellectual Property	4	4	1.96	54.90	11
FND	Representation of Numeric and Character Data	4	4	0.98	55.88	19
MATH	Discrete Mathematics	4	4	0.98	56.86	19
MATH	Optimization	4	4	0.98	57.84	19
ARCH	General Purpose Processor	4	4	0.98	58.82	19
ARCH	Hardware Interface	4	4	0.98	59.80	19
ARCH	Control Engineering	4	4	0.98	60.78	19
ARCH	High Performance Computing	4	4	0.98	61.76	19
OS	Basic Concepts	4	4	0.98	62.75	19
OS	Organization and Evaluation of Operating System	4	4	0.98	63.73	19
OS	Implementation of Operating System	4	4	0.98	64.71	19
MM-DP	Application of Multimedia Data Processing	4	4	0.98	65.69	19
HUI	Interaction and HMI	4	4	0.98	66.67	19
Usability	Usability Design	4	4	0.98	67.65	19
Usability	Usability Evaluation	4	4	0.98	68.63	19
Telecomm	Communication Technology	4	4	0.98	69.61	19
Telecomm	Law, Social System, Standardization	3	3	0.98	70.59	19
NET	Implementation of Computer Network	4	4	0.98	71.57	19
NET	Network Management	4	4	0.98	72.55	19
NET	Distributed System	4	4	0.98	73.53	19
WEB	Web Software	4	4	0.98	74.51	19
Security	Network Security	4	4	0.98	75.49	19
Security	Authentification	4	4	0.98	76.47	19
DB	Database System Concepts	4	4	0.98	77.45	19
DB	Database Language	4	4	0.98	78.43	19
DB	DBMS	4	4	0.98	79.41	19
DB	Transaction Management	4	4	0.98	80.39	19
DB	Logical Database Design	4	4	0.98	81.37	19
DB	Physical Database Design	4	4	0.98	82.35	19
DB	System Development, Management, Operation	4	4	0.98	83.33	19
DB	Specific DBMS	4	4	0.98	84.31	19
ALGO	Data Structure	4	4	0.98	85.29	19
ALGO	Basic Algorithms	4	4	0.98	86.27	19
ALGO	Algorithm Design	4	4	0.98	87.25	19
PRG	Specific Programming Language	4	4	0.98	88.24	19
SWE	Metrics and Measurement	3	3	0.98	89.22	19
SWE	Software Reuse	4	4	0.98	90.20	19
PM	Fundamental Concepts	4	4	0.98	91.18	19

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
PM	Time Management	3	3	0.98	92.16	19
PM	Cost Management	3	3	0.98	93.14	19
PM	Quality Management	3	3	0.98	94.12	19
OPR	Maintenance	4	4	0.98	95.10	19
Business	Law and Ethics	3	3	0.98	96.08	19
Business	Accounting	3	3	0.98	97.06	19
Business	Marketing	3	3	0.98	98.04	19
Business	Decision Making	4	4	0.98	99.02	19
SOC	Information Ethics	3	3	0.98	100.00	19

A.3.4 Information Security Engineer Examination (SC)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Security	Security Management	4	5	17.65	17.65	1
OPR	Evaluation	4	5	17.65	35.29	1
SWE	Validation and Testing	4	5	14.71	50.00	3
OPR	Planning	4	5	14.71	64.71	3
Security	Security and Society	4	5	8.82	73.53	5
COMM	Reading, Writing, Presentation	4	5	8.82	82.35	5
SWE	Requirement Analysis	4	5	5.88	88.24	7
SWE	Software Architecture	4	5	5.88	94.12	7
SWE	Structured Analysis and Design	4	5	2.94	97.06	9
SWE	Software Process	4	5	2.94	100.00	9

A.3.5 Network Specialist Examination (NW)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
Telecomm	Development, Management and Operation	4	5	16.67	16.67	1
SWE	Requirement Analysis	4	5	13.33	30.00	2
OPR	Evolution	4	5	13.33	43.33	2
NET	Network Management	4	5	10.00	53.33	4
SWE	Validation and Testing	4	5	10.00	63.33	4
OPR	Planning	4	5	10.00	73.33	4
OPR	Evaluation	4	5	10.00	83.33	4
Security	Security Management	4	5	3.33	86.67	8
SWE	Software Architecture	4	5	3.33	90.00	8
PM	Fundamental Concepts	4	5	3.33	93.33	8
OPR	Maintenance	4	5	3.33	96.67	8
Business	Decision Making	4	5	3.33	100.00	8

A.3.6 Project Manager Examination (PM)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
PM	Management on Others	4	5	25.00	25.00	1
PM	Time Management	4	5	19.44	44.44	2
PM	Fundamental Concepts	4	5	11.11	55.56	3
PM	Cost Management	4	5	11.11	66.67	3
PM	Quality Management	4	5	5.56	72.22	5
PM	Acquisition Management	4	5	5.56	77.78	5
OPR	Planning	4	5	5.56	83.33	5
OPR	Evaluation	4	5	5.56	88.89	5
COMM	Reading, Writing, Presentation	4	5	5.56	94.44	5
COMM	Practical Skill	4	5	5.56	100.00	5

A.3.7 System Architect Examination (SA)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
SWE	Requirement Analysis	4	5	15.93	15.93	1
SWE	Validation and Testing	4	5	14.16	30.09	2
OPR	Planning	4	5	14.16	44.25	2
OPR	Operation	4	5	10.62	54.87	4
SWE	Object Oriented Analysis and Design	4	5	7.08	61.95	5
SWE	Structured Analysis and Design	4	5	6.19	68.14	6
OPR	Evaluation	4	5	6.19	74.34	6
OPR	Maintenance	4	5	4.42	78.76	8
SWE	Software Process	4	5	2.65	81.42	9
Business	Decision Making	4	5	2.65	84.07	9
COMM	Reading, Writing, Presentation	4	5	2.65	86.73	9
SWE	Data Modeling	4	5	1.77	88.50	12
SWE	Software Architecture	4	5	1.77	90.27	12
SWE	Software Reuse	4	5	1.77	92.04	12
PM	Fundamental Concepts	4	5	1.77	93.81	12
OPR	Evolution	4	5	1.77	95.58	12
OS	Specific OS	4	5	0.88	96.46	17
DB	Logical Database Design	4	5	0.88	97.35	17

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
SWE	Software Development Environment	4	5	0.88	98.23	17
PM	Cost Management	4	5	0.88	99.12	17
PM	Acquisition Management	4	5	0.88	100.00	17

A.3.8 Database Specialist Examination (DB)

Field	Area	Req.Level		Importance Level		
		KLG	SKL	%	Acc %	Rank
DB	System Development, Management, Operation	4	5	55.56	55.56	1
DB	Logical Database Design	4	5	22.22	77.78	2
SWE	Requirement Analysis	4	5	16.67	94.44	3
DB	Physical Database Design	4	5	5.56	100.00	4

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