Transforming "Informatics" Subjects in Japanese High Schools

— Expanding ICT Usage for 21st Century Education —

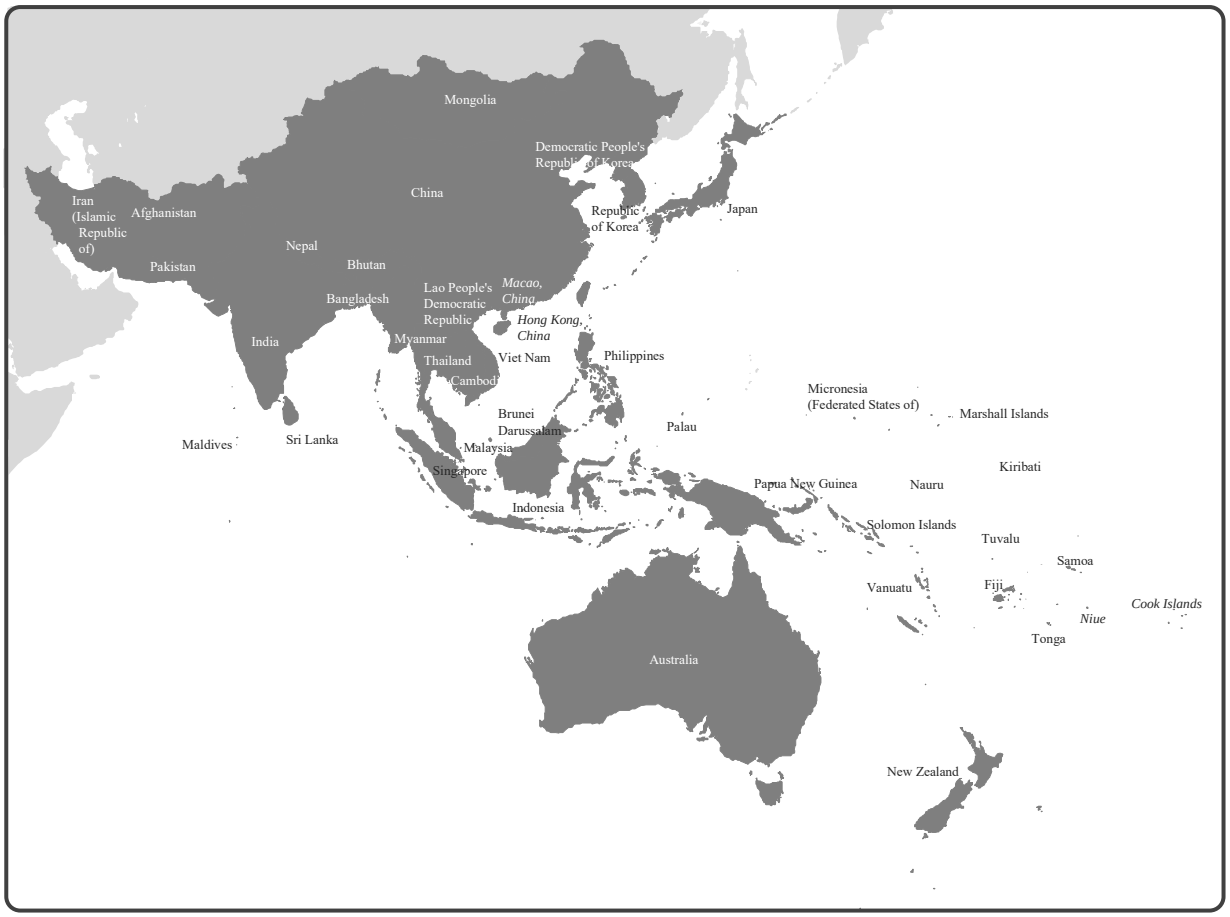
Asia-Pacific Telecommunity (APT) is the only intergovernmental organization specialized in the ICT field in Asia-Pacific region, established in 1979 by the joint initiatives of the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the International Telecommunication Union (ITU) with the objective of fostering the development of telecommunication services and information infrastructure throughout the region, particularly focus on developing areas.

Through its various programmes and activities focused on 5 Strategic Pillars as follow, the APT continues to support and assist its 38 members, 4 associate members and 144 affiliate members (as of September 2023) to realize the positive benefits of ICTs and cope with the challenges of rapidly evolving ICT environments.

For further information, please visit the APT website at https://www.apt.int.

Strategic Pillars of the APT (Strategic Plan of the APT for 2021-2023)

a. Connectivity: Enhancing access and efficiency of digital infrastructure.
b. Innovation: Enabling conducive environments and harnessing the benefits of telecommunication/ICT.
c. Trust and Safety: Ensuring secure cyberspace, security and resilience through telecommunication/ICT.
d. Inclusion and Capacity Building: Promoting inclusiveness and enhancing digital skills and literacy.
e. Collaboration and Partnership: Solidifying strategic collaboration with stakeholders.



38 Members and 4 Associate Members of the APT

APT Publication of Research for
Information Sharing on ICT Policy and Development for 2021

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-Expanding ICT Usage for 21st Century Education -

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－ Expanding ICT Usage for 21st Century Education－

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Published in Thailand by
Asia-Pacific Telecommunity
12/49 Soi 5, Chaeng Watthana Road, Thungsonghong, Lak Si,
Bangkok 10210, Thailand
+66 2 573 0044
https://www.apt.int

Printed in Japan by
KDDI Foundation
3-10-10, Iidabashi, Chiyoda-ku,
Tokyo 102-8460, Japan

ISBN: 978-4-907714-94-9

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Preface

As we enter the 2020s, the implementation of artificial intelligence and IoT in society is progressing, and the importance of ICT in society is increasing. However, there is a shortage of human resources with advanced ICT skills and a growing need to review educational styles.

In Japan, the government is trying to shift to a 21st-century educational model by improving the ICT environment in schools and recently enriching the subject "Informatics," especially in upper secondary high schools.

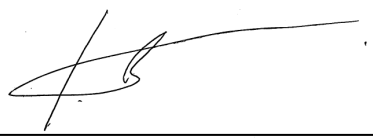
This publication is the result of a project carried out as an extension of the 2016 APT project, "APT Publication of Research for Information Sharing on ICT Policy and Development," which was published in 2018 with the title of "Approaches to Fostering 21st-Century ICT Capabilities for Future Generations in APT Countries."[1]

This research project focuses on reforming "Informatics I" in Japanese upper secondary schools. This publication explains how and under what circumstances and initiatives "Informatics I," which became a required course in the 2022 academic year. It also introduces the features of each of the 12 "Informatics I" textbooks published.

In addition, the Appendix includes the "Informatics I" section of the Courses of Study, a sample examination of the Common Test "Informatics I," and the tabulation results of index terms from 12 textbooks of "Informatics I." We hope the readers will find it helpful along with the main text.

This publication resulted from collaborations between industry, government, and academia. The project members came from the KDDI Foundation as a project-implementing agency, the Multimedia Promotion Center (FMMC) as a non-profit organization, and Chuo University, Shizuoka University, and Meiji University as academic institutions.

Finally, we hope that the contents of this publication will be of use to all APT countries and that it will also contribute to information sharing and networking among APT countries.



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[1] Accessible at https://www.apt.int/sites/default/files/Upload-files/ICT/Projects/New%20folder/Piblication_2016_KDDI_v400_APT_FINAL.pdf .

Executive Summary

This publication aims to introduce the reform of the subject "Informatics" in Japan and provide information for international exchange. "Informatics" was taught as an independent subject in the early 2000s in regular upper secondary schools (hereafter referred to as high schools). It underwent several reforms before adopting its current form. In Japanese high schools, "Informatics I," which includes programming studies, has become compulsory since 2022, and the ICT environment has been improved along with the reform.

The "Introduction" of this book provides background and an overview, followed by the start of Informatics education in high schools in Japan (Chapter 1), the expansion of Informatics education (Chapter 2), and the characteristics of the "Informatics I" textbooks (Chapter 3). The "Final" chapter summarizes this book and mentions its outlook and future issues. This book also includes three appendices as reference material.

In Japan's educational system, "The Courses of Study" by the Ministry of Education, Culture, Sports, Science, and Technology (hereafter referred to as MEXT) provides broad educational content and method guidelines[2]. Multiple publishers offer textbooks based on it, and each school selects textbooks according to its needs and goals. The MEXT prepares the Courses of Study based on a Central Council for Education report. In doing so, the Central Council for Education prepares a report in consultation with the MEXT Minister. The Courses of Study are revised approximately every ten years.

The content of "Informatics I," taught in regular high schools, is based on the Courses of Study published in 2018. This is new because it adds programming studies and contains most of the previous learning items. In addition, "Informatics I" will be administered as an independent subject in "The Common Test for University Admissions" (the Common Test) from 2025[3]. In Japan, 12 different "Informatics I" textbooks have been published with varying levels of difficulty and focus areas; high schools are free to choose the textbook that best suits their needs and goals.

The Courses of Study of 2018 sought to develop the following four qualities and abilities in "Informatics I" education. The restructured parts from the previous subject are a, b, and d. An additional requirement is d. All four elements are now required to be learned in high schools in Japan.

a. Solving the problems of the information society

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[2] The explanation of "the Courses of Study" in English can be found by clicking on the following URL (hereafter shortened as See). https://www.mext.go.jp/en/policy/education/elsec/title02/detail02/1373859.htm

[3] See https://www.nicjp.niad.ac.jp/en/japanese-system/admission.htm for the explanation of "The Common Test for University Admissions" and Admission Qualifications and Pathways in Higher Education in English.

b. Communication and information design
c. Computers and programming
d. Utilization of information communication networks and data

From an international comparative perspective, Japan's “Informatics I” is characterized by its emphasis on the philosophy of solving social issues. In other words, while inheriting its uniqueness, Japan caught up with international trends by introducing programming studies.

Behind the reform, as mentioned above, is the “Basic Act on Education,” revised in 2006 for the first time in 59 years, and the “Basic Plan for the Promotion of Education,” formulated every five years under the Act[4]. Based on this plan, the ICT environment in schools has greatly improved in Japan under the GIGA School concept, which covers elementary and high schools and provides wireless broadband and one PC per student.

As described above, the subject “Informatics I” has been reformed in Japan in these 20 years with a rapid shift to ICT-based education. After 2020, students learned programming from elementary school to high school. Since the Japanese government has taken the necessary institutional and budgetary measures, students are now benefitting from updated ICT environments, ICT equipment, digital textbooks, teaching materials, and qualified teachers.

Even with these reforms in “Informatics” in Japan, issues still pertain. In addition to curriculum overload, there is a need for more effective approaches to meet increasingly diverse educational needs. Recognizing these issues, MEXT will release the revised Courses of Study around 2027 to show the direction of both individually optimized and collaborative learning. The Japanese government believes that it is essential to balance individually optimized learning and collaborative learning, which fosters creativity and ensures that no one is left behind to survive this era of rapid ICT change.

Globally, many countries have introduced “Informatics” and are promoting the use of ICT in education. In this context, Japan's experience in reforming “Informatics” subjects can serve as a reference for other countries. We hope that this book will contribute to international mutual exchange.

[4] See https://www.mext.go.jp/en/policy/education/lawandplan/title01/detail01/1373797.htm.

Content

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Introduction: Transforming “Informatics” in Japan

1 “Informatics I” as a required subject in high school in Japan from AY2022

In Japan, “Informatics I” has become a required subject for regular public high school courses since April 2022. In addition, the subject “Informatics I” will be introduced in the Common Test for University Admissions (the Common Test) to be administered in January 2025. A new subject was added to the Common Test for the first time in 21 years. The main feature of the newly introduced “Informatics I” is that it expands and modifies the content of the previous Informatics subjects, making the study of programming a mandatory learning element. Consequently, the textbooks for “Informatics I” have been substantially revised, and high schools begin using the new “Informatics I” textbooks from April 2022 with the start of the academic year.

This book distinguishes between “Informatics” as a subject and “Informatics Studies” as a specialized course or vocational education in specialty high schools. “Informatics I” focuses mainly on the introduction and development of the subject “Informatics” in regular high schools.

2 Why “Informatics I” is important? Programming and the Common Test

While countries worldwide are expanding Informatics education, including programming, from elementary school, Informatics education at the high school level is also undergoing transformation. In Japan, the academic year 2022 (hereafter AY2022) marks a major milestone, when “Informatics I” became a mandatory course in high schools.

One of the reasons for this is that programming, which was not previously mandatory, has become mandatory, and the fundamentals of programming are now included in “Informatics I” textbooks. In Japan, programming studies will begin in elementary schools in 2020 and junior high schools in 2021, prior to high schools. However, programming education in elementary and junior high schools has been introduced as an additional element within existing subjects such as Japanese, mathematics, and music, and not as an independent subject. On the other hand, “Informatics I” in high schools is an independent subject. Consequently, the Common Test in Japan changed from five subjects with seven courses to six subjects with eight courses.

3 Textbooks and supplementary materials for “Informatics I”

These major changes in informatics education at the high school level in Japan have been discussed and analyzed mainly in Japan, and empirical research on educational effects has begun at this stage. It might be too early, considering the research situation in Japan; however, it would be beneficial to introduce this transformation in Japan as an English report to expand international mutual understanding. Particularly in Japan, the 12 “Informatics I” textbooks with supplemental digital contents were published. These textbooks have received attention from various sectors of Japan, including businesspeople, because of their rich content and social needs. Each textbook, while conforming to the framework of the Courses of Study established by the MEXT, has its own distinctive content, with differences in the level of difficulty and emphasis placed on the

subject. In addition to being published in paper form, the textbooks are also produced in conjunction with digital textbooks and online teaching materials, thus responding to the digitalization of the education field.

4 The transition of "Informatics" education in Japan

In this book, we will examine the history and background of the reform and transformation of Informatics education at the high school level, and confirm how those changes have affected the introduction of "Informatics I." This book also reviews the process of incorporating the changes in educational vision into specific educational content and textbooks within the Japanese educational system and confirms the current status of Informatics education at the high school level. In addition, this book presents the characteristics of the 12 textbooks.

Based on the above description, this book points out that Informatics education at the high school level in Japan is undergoing three transformations:1) a shift in the perception of academic achievement, 2) a shift in educational content, and 3) a shift in educational methods. These changes are affected by progress in Information Communications Technologies (ICT). It is also noted that this transformation will not be realized in a short period of time, but rather that the transformation has just begun, and many issues remain to be addressed.

5 Future of "Informatics" education with ICT Usage in Japan

In 2016, the Japanese government launched "Society 5.0," a vision for future Japanese society, in its Fifth Science and Technology Basic Plan to address various issues such as the slow pace of digitization and the declining birthrate and aging population. During the same time, MEXT published the Courses of Study in March 2017 based on the report to the MEXT Minister by the Central Council for Education in December 2016. The Courses of Study 2017 made "Information I" as compulsory at the high schools from 2022. Subsequently, new discussions are underway to prepare a new report for the MEXT Minister on the transformation of the education and human resource development system in Japan. In the subsequent report, the direction would be to realize "individually optimized and collaborative learning" that draws out the potential of all children with ICT considering related reports and discussions.

6 Expanding "Informatics" education in the world

Japan is not the only country where changes in Informatics education are occurring. For example, a report by the European Commission published in 2022 compared the state of "Informatics" education in EU member countries. Almost every country except Iceland and a few other regions offers some forms of "Informatics" education at the high school level (European Education and Culture Executive Agency, 2022, p. 29). The report also says that the subjects concerning "Informatics I" differ among EU member countries in the following four aspects (European Education and Culture Executive Agency, 2022, pp. 20-23, 42).

1) Starting grade of Informatics education

2) Whether it is an independent subject or included in other subjects.

3) Whether it is a required or elective subject

4) Educational Content[5]

Based on these perspectives, “Informatics I” in Japanese high schools has been an independent subject and a mandatory course since 2003, its content has been expanded, and programming has become a required course since 2022.

7 Toward mutual information exchange of “Informatics” education

The main purpose of this book is to highlight the above-mentioned changes and significance of “Informatics I,” which aims to develop the skills and abilities related to the four leaning items of the subject as listed below.

a) Solving the problems of the information society

b) Communication and information design

c) Computers and programming

d) Utilization of information communication networks and data

These four items could be matched to the ten learning items in the European Report, as shown in Table Intro.

[5] The report summarizes the differences among countries in the following ten key areas of the “Informatics” leaning items: 1 Data and information, 2 Algorithms, 3 Programming, 4 Computing systems, 5 Networks, 6 People-system interface, 7 Design and development, 8 Modulation and simulation, 9 Awareness and empowerment, 10 Safety and security.

Table Intro. Leaning items of "Informatics I" in Japan and in European Countries

Leaning items of the Japanese subject "Informatics I"	Learning Items of the European Report
a) Solving the problems of the information society	9 Awareness and empowerment 10 Safety and security
b) Communication and information design	6 People-system interface 7 Design and development
c) Computers and programming	2 Algorithms 3 Programming 4 Computing systems
d) Utilization of information communication networks and data	1 Data and information 5 Networks 8 Modelling and simulation

Before 2022, there were multiple options for high schools in Japan, and it was possible to focus only on literacy to use IT devices and information society issues. However, programming study became mandatory in "Information I," incorporating content from previous advanced subjects such as "Informatics B" and "Science of Information." This made "Informatics I" a more computer science-oriented subject.

8 The structure of this book

After providing background information and an overview in the introductory chapter, this book introduces 1) the start of Informatics education (Chapter 1), 2) the expansion of Informatics education (Chapter 2), and 3) the characteristics of the "Informatics I" textbooks (Chapter 3). In the final chapter, a summary of this book, its future prospects, and remaining issues are described.

Chapter 1 provides an overview of the educational reform process in Japan, followed by a review of the changes in Informatics education at the high school level in the 2000s. Chapter 2 summarizes how "Informatics I" at the high school level was made compulsory from 2022, based on the discussion on Informatics education in the 2010s. In Chapter 3, the characteristics of the 12 different "Informatics I" textbooks will be addressed.

This publication is written in English with the aim of disseminating information on the situation in Japan to contribute to the promotion of international exchange in Informatics education.

In addition, the following three appendices are attached to this book as reference material:

Appendix 1: Excerpts from the Courses of Study (Informatics I)

Appendix 2 An analysis of the indexed terms of the 12 textbooks of "Informatics I"

Appendix 3: Prototype test of the Common Test subject “Informatics I”

Chapter 1 The Beginning of "Informatics" Education in the 2000s

Introduction: The educational reform process and the introduction of "Informatics"

One of the unique features of the Japanese education system is that educational content and methods are regularly updated through revisions of the Courses of Study released by MEXT. The Courses of Study are developed for all subjects in elementary, junior high, and high school, and summarize the objectives, content, and methods of education. The Courses of Study are revised approximately every 10 years, so it is possible to keep track of changes in Japanese education by looking at revisions of that.

The changes in the instruction of "Informatics I" in Japan can also be seen from the changes in the contents of the Courses of Study. In Japan, "Informatics" education in high schools had been implemented sporadically in individual schools since the 1960s; the Courses of Study in 1989 introduced "Informatics" related education nation-wide as leaning items rather than as a specific subject in elementary, junior high, and high schools (Fujima, 2008). In subsequent years, the curriculum was introduced as a subject in all elementary and junior high schools. Later, in 2003, the 1999 Courses of Study made Informatics an independent subject in regular high schools.

This chapter provides an overview of the educational reform process in Japan, and summarizes the early period of "Informatics" education in high schools, introduced by the Courses of Study in 1999 and restructured by the Courses of Study in 2008/2009.

1.1 Overview of the education reform process in Japan

(1) The role of the Central Council for Education and its report

As previously mentioned, the report to MEXT Minister by the Central Council for Education in December 2016 and the next Courses of Study in March 2017 made "Informatics I" mandatory in Japanese high schools. The Central Council for Education was established within the MEXT in 1952, and its role is to study and deliberate important matters related to education in response to consultations from the MEXT Minister and to provide opinion reports to the Minister (MEXT, 2023, April 17, pp. 206-208). The MEXT Organization Ordinance established the Central Council for Education. The Central Council for Education is a research organization and institute. In addition to research institutes and schools, the Central Council for Education has members from a variety of organizations, including nonprofits, local governments, and businesses (Cabinet Office, 2000).

The Central Council for Education became the current organization in 2001 after its reorganization (MEXT, 2001, January 6). The Central Council for Education's report reflects the direction of education that should be pursued, considering the issues in Japanese education at the time each report was published (Horikiri, 2004). Before the report is issued, various surveys,

hearings with related parties, and discussions in the council will be conducted, and opinions on the draft report will be solicited.

The reports issued by the Central Council for Education cover the entire field of education in Japan and are diverse in content. In addition to reports on the ground design of education in Japan, the Council has issued reports on the establishment of standards for schools. Based on these reports, MEXT decides on and develops specific educational policies. In other words, reports from the Central Council for Education led to the transformation of Japan's educational system.

(2) The report by the Central Council for Education and the Courses of Study

In Japan, the MEXT has published the "Courses of Study" as standards for organizing curricula at each school. Since 1958, the Courses of Study have been set forth in the form of ministerial announcements (MEXT, 2009). In Japan, the Courses of Study are designed to ensure that students receive a certain level of education, regardless of where they are educated.

The Courses of Study have been revised approximately every ten years in response to changes in society, the accompanying changes in views on education and learning, and the role of education. Prior to the revision of the Courses of Study, the Central Council for Education reports on how to improve them. For example, the Council narrowed down the volume of educational items considering the adverse effects of education that entailed cramming facts in the past with the goal of "realizing a pressure-free and fulfilling school life" in 1977 and 1978. However, the number of class hours was reduced, leading to a reduction in the number of learning activities that utilized knowledge. It also caused some unexpected adverse effects, rather than moving away from knowledge-oriented education, which was the original goal of the "pressure-free education." Acknowledging the result, the 2008 Courses of Study increased the content of study while emphasizing the "the abilities to live," and shifted to a policy of "post-pressure-free" education (Yahoo! News Editorial Team, 2017, March 17; MEXT, 2009a). The policy was to increase the volume of leaning content while emphasizing "the abilities to live."

(3) The current state of education in Japan: school and university entrance examinations

In Japan, elementary and junior high school education is compulsory, whereas high school education is not. However, the percentage of students entering high school will exceed 95% in 2020 and 98.8% if correspondence high schools are included; therefore, most will go on to high school (Elementary and Secondary Education Bureau, MEXT, 2021).

Table 1 - 1 indicates that almost all elementary schools in Japan and more than 90% of junior high schools are public. The percentage of private schools increased in high schools, 27% of which are private. Universities are mostly private, with the percentage reaching 77%.

Table 1 - 1 Number of Schools and Percentage of Private Schools in Japan

School Type	Total number	Private	National	Public	Percentage of private institutions
Post-secondary education institution, incl. university, college, etc.	795	615	86	94	77.4%
High school	4,874	1,322	15	3,537	27.1%
Junior high school	10,142	782	69	9,291	7.7%
Elementary school	19,525	240	68	19,217	1.2%

Source: PMAC (2020).

The Courses of Study apply to private schools as well as national and public schools (PMAC, 2020) The first-round examination for national and public universities is called the Common Test. The test is the same throughout the country and test scores are available to all universities. Many schools implement their own entrance examinations in the second round. Private universities often administer the school's own examinations, but some schools use scores from the Common Test. Therefore, students who wish to attend national and public universities are required to take the Common Test.

According to a private tutoring school preparing university entrance examinations, 73 percent of national and public universities will require seven or more subjects on the Common Test in 2023 (Kawaijuku, 2023). In other words, national universities require applicants to take both humanities- and science-related subjects, regardless of whether they are taking humanities- or science-oriented courses in high schools. In addition, “Informatics I” will be implemented from 2025 as the Common Test subject. In conjunction with this, the number of subjects for the Common Test has been restructured from 30 courses in six subjects to 21 courses in seven subjects. “Informatics I” is counted as one subject/course. Although the requisite number of subjects and courses for the Common Test differ based on the university, 97% of national universities require students to take “Informatics I” as of April 2023 (Kawaijuku, 2023). On the other hand, in private universities, 15% of respondents answered that they planned to include “Informatics I” for their entrance examination subjects and 74% answered that they were considering including it, according to the May 2022 survey. Even among the private universities that responded that they were considering using it, the majority used it for some of their entrance examinations[6].

The background and circumstances that led to the introduction of “Informatics I” in the Common Test will be reviewed in the next section and thereafter, and its significance will be discussed.

[6] In Japan, most private universities offer several forms of entrance examinations.

1.2 The 1999 Courses of Study and the start of "Informatics I" in regular high schools

(1) Start of Informatics education in regular high schools (2003-2013)

The history of "Informatics" education in Japan up to the 1990s is outlined in the "120 Year History of the School System" by the MEXT (MEXT, 1992). In the 1990s, MEXT established the Council for Cooperative Research and Survey on the Promotion of Information Education in Elementary and Secondary Education in Response to the Advancement of Information Technology and held its first meeting in October 1996. Followed by the submission of the final report in 1998, which emphasized the development of the ability to utilize information. Specifically, the report set the development of practical ability to use information, scientific understanding of information, and attitude to participate in the information society as educational goals (MEXT, 2003).

The 1999 Courses of Study stipulated that high schools select one of the three subjects, "Informatics A," "Informatics B," or "Informatics C," to be studied[7]. The goal was to cultivate a scientific view and way of thinking about information through the acquisition of knowledge and skills to use information and information technology, help students understand the role and impact of information and information technology in society, and develop the ability and attitude to proactively respond to the progress of information technology. The emphases on these subjects are as follows:

- ✓ "Informatics A": Acquire basic knowledge and skills and develop an attitude toward using information proactively.
- ✓ "Informatics B": Acquire scientific ideas and methods for using computers in problem solving.
- ✓ "Informatics C": Cultivate desirable attitudes toward participating in an information society.

However, Ooiwa (2020) pointed out that programming in "Informatics B" was not practical, but rather knowledge-based.

(2) Completion policy and the untaught issue of "Informatics A, B and C"

As stated above, Informatics education in regular high schools based on the 1999 Courses of Study required students to take one of the following subjects: "Informatics A," "Informatics B," or "Informatics C." Since those subjects were introduced as new subjects, MEXT offered a course over a three-year period to certify their teaching ability for in-service teachers, and trained 14,200 teachers with a teaching license in Informatics education. It was estimated that 85% of high schools would choose "Informatics A," 5% would choose "Informatics B," and the rest 15% would choose "Informatics C" (Kawase & Kita, 2021). "Informatics A" focused on the development of literacy in the use of IT equipment. "Informatics B" included computer science and programming. The

[7] Although the direct translation of these subjects are Information A, B and C. this report adopted the word of "Informatics," considering the content.

main content of “Informatics C” was information society. Since only 5% of high schools chose “Informatics B” at the start of 2003, most of the Informatics education in Japanese regular high schools was focused on acquiring skills in the use of IT equipment.

Subsequently, in 2006, some high schools did not offer sufficient Informatics learning periods due to factors such as a shortage of teachers for newly introduced Informatics education in regular high schools (Kanemune, 2006, December 16). In Japan, even if a course is required but is not yet practically completed, students can graduate if the number of credits in other courses meets the graduation requirements. Thus, Japan basically adopts the “course completion policy,” wherein students are considered to have learned the content of a given educational course by completing it within a certain number of years. Even in cases where students were considered to have completed the course, there were high schools where the study time was short and only one credit was given to “Informatics” (the required credit of “Informatics” was two credits at that time) (IPSJ, 2006).

(3) “Informatics A, B, and C” and their position in the Common Test

In November 2006, the Information Processing Society of Japan (IPSJ) published a recommendation titled “The Problem of Untaught ‘Informatics I’ in High Schools, Its Impact on the Future of Japan, and Countermeasures” (IPSJ, 2006). The proposal recommended to enhance the treatment of “Informatics” in university entrance examinations, considering the negative impact faced by students who were not taught the subject in school when they encountered it in university.

In Japan, there are technical high schools and other high schools offering vocational education in addition to regular high schools. In technical high schools, education related to information processing technology has been provided since the 1960s, and a basic course in information technology was established in 1989 (Motomura, 2021). At that time, the content of the “Fundamentals of Information Technology” subject for technical high schools was not an independent university entrance examination subject, but was included as an elective mathematics question on the Common Test (Nakano et al., 2021) Therefore, IPSJ pointed out that there was no positive reason found for implementing Informatics subject classes for students in regular high schools, especially in high schools with higher college enrollment rates since very few universities included “Informatics” content in their entrance examinations (IPSJ, 2006). In other words, in Japan, subjects not included in university entrance examinations tend to have lower priority in regular high schools.

On the other hand, the number of students entering technical high schools, which have provided Informatics education in specialized courses, continued to decline. In 1955, the number of students in technical high schools accounted for 40% of the total, but by 2022, it had dropped to 17% (MEXT, 2022b). In addition, some technical high schools offer electrical and architectural specialties, and Informatics specialties are studied only in a small portion of technical high schools (Expert Group on Technical High Schools in an Advanced IT Society, 2019). The number of high school students studying Informatics at technical high schools is estimated to be approximately

3,000 (Nakano et al., 2021) In addition, specialized high schools have begun to offer Informatics science courses (Numazaki et al., 2014). As of 2022, the number of students was only 2,698 (MEXT 2022).

This suggests that there was little incentive to select Informatics as an elective mathematics question in the Common Test, and the number of potential examinees declined owing to the decrease in the number of students from technical high schools. In the 2023 Common Test, the total number of examinees was approximately 474,000 and 367,000 examinees selected "Mathematics II and B." However, only 410 students took "Fundamentals of Informatics" as the elective question (National Center for University Entrance Examinations, 2023).

1.3 The 2008/2009 Courses of Study and the restructuring of Informatics subjects (2013-2021)

(1) "Basic Act on Education" and the First Basic Plan for the Promotion of Education

MEXT published its revised Courses of Study from 2008-2009 (MEXT, 2009b). The 2008/2009 Courses of Study was revised to improve the quality of classroom education. As mentioned earlier, the 2008/2009 Courses of Study emphasized the balance between the acquisition of knowledge and skills and the development of thinking, judgment, expression, and other skills.

Prior to the 2008/2009 Courses of Study, the "Basic Act on Education" was revised and enacted in 2006. The law was first amended in 2006, 59 years after its enactment in 1947 (Obunsha Educational Informatics Center, 2007). The 2006 amendment was noteworthy, because the preamble added the objective of establishing and promoting the fundamentals of education, which would pave the way for the future. It also included the government's formulation of basic plans for promoting education.

Based on this act, the first "Basic Plan for the Promotion of Education" was released in 2008. The plan covered the period from 2008 to 2012, and the following two directions were set forth as the course of action for the next 10 years (MEXT, 2008).

- ✓ Provide all children with a foundation to live independently by the end of their compulsory education
- ✓ Foster human resources to lead the international community at supporting and developing society

The first phase of the plan also described efforts to promote ICT in the educational field, improve teachers' teaching skills, and create teaching materials using ICT. As discussed later, the Basic Plan for the Promotion of Education from the second phase onward also emphasized the development of ICT environments and the use of ICT (MEXT, 2008).

(2) The Courses of Study 2008/2009 and the reorganization of "Informatics" subjects

The 2008/2009 Courses of Study, released at the same time as the first Basic Plan for the Promotion of Education, adopted the policy of de-literalizing education and expanded the study time for major subjects, such as Japanese and arithmetic, in elementary and junior high schools. In high schools, it also emphasized science, mathematics, and English, with the aim of improving students' competitiveness in a global society (Kyoikujin, 2008, December 24). The Informatics education system expanded its focus to include information technology. Regarding that, the contents of the existing "Informatics A," "Informatics B," and "Informatics C" courses were reorganized and combined into two courses: "Society and Information" and "Science of Information."

Table 1 - 2 Reorganization of old and new subjects

New subjects	Old subjects
"Society and Information"	Informatics A, Informatics C
"Science of Information"	Informatics A, Informatics B

Source: By the author from various sources.

In other words, the content of "Informatics A" was taken over by both "Society and Information" and "Science of Information," while "Informatics B" was mainly taken over by "Science of Information" and "Informatics C" was mainly taken over by "Society and Information" (MEXT, 2010, p. 14) The "Informatics A" textbooks were taken over by the "Informatics B" textbooks. However, the adoption rates of "Informatics A" and "Information and Society" textbooks were high at 72.4% and 80.9 (Akazawa et al., 2022, p. 2) The adoption rate of "Informatics A" textbooks was 72.4% and 80.9%, respectively.

(3) "Integrated learning" and curriculum overload

The 2008/2009 Courses of Study increased the content of study and emphasized the use of knowledge and skills learned beyond the boundaries of academic subjects, called "Integrated Study" or "Inquiry Based Learning." The introduction of this learning style can be traced back to the 1960s, but it was clarified and introduced into school education in earnest after the 1998 Courses of Study (Gamo, 2020).

This curriculum overload problem was originally referred to as cramming education ("Tsumekomi in Japanese which means to force students to absorb knowledge and information in a short period of time) to and was seen as a problem in the 1970s. However, as the adverse effects of the reduction in learning content in the 1998 Courses of Study were also observed, learning content was revived in 2008/2009, and the curriculum overload problem was once again recognized as an issue. (Aida, 2001, pp. 21-23).

Chapter Summary

This chapter overviewed the process of making “Informatics I” a mandatory course in Japanese high schools. Although it is difficult to describe the entire picture because of the multifaceted nature of the educational system, the following characteristics of the Japanese educational system can be identified within the scope of this chapter.

- ✓ The report by the Central Council for Education to the MEXT Minister influenced the medium-term direction of education in Japan.
- ✓ The Courses of Study are revised approximately every 10 years based on the reports of the Central Council for Education.
- ✓ Under the 1999 Courses of Study, high school students began to learn the subject of “Informatics” in 2003.
- ✓ Programming was not required for the subject “Information A, B and C” which began in 2003.
- ✓ The subjects of Informatics were reorganized according to the 2008/2009 Courses of Study into “Society and Information” and “Science of Information.”
- ✓ Under the above Courses of Studies, “Informatics” did not become an independent subject for university entrance examinations.
- ✓ In the Common Test in the above period, Informatics subjects were electives in mathematics, and the number of examinees was very small.
- ✓ Under the 2008/2009 Courses of Study, the curriculum overload problem has resurfaced.

Based on these characteristics, Japan's education system has been changing on a decade-by-decade basis, with the Central Council for Education's report and Courses of Study revised to respond to changes in the social environment. In the 2000s, Informatics education was in a transitional period from specialized to general subjects, and the development of ICT environments in schools was not in full swing. Rather, curriculum overload resurfaced as an issue as learning content expanded, and emphasis was placed on developing integrated skills to respond to an increasingly complex society. These challenges continued into the 2010s and are reviewed in the next chapter.

Chapter 2 The expansion of “Informatics” Education in the 2010s

Introduction Improvement of ICT environments and “Informatics” education

Chapter 2 provides an overview of the expansion of “Informatics” education in high schools in the 2010s. As summarized in Chapter 1, “Informatics” education in regular high school courses began in Japan in the early 2000s, but several issues remained.

Later, “Informatics” education was expanded mainly in the form of 1) revision of the Courses of Study and introduction of programming studies, 2) strengthening smooth transition from high school to university education and making the Common Test subject “Informatics I,” and 3) improvement of ICT environment in schools in the 2010s, with the further development of the information society and the growing importance of Informatics education,

However, new issues are already emerging in the implementation of “Informatics I,” which was introduced in 2022. For example, teachers feel concerns about preparation for the Common Test subject “Informatics I” as they lack instructional knowledge especially in programming (ReseEd, 2021). Now, the “Informatics I” subject has become pivotal in high school.

Based on the above, this chapter reviews the expansion of “Informatics” education in the 2010s, and introduces some reports on the trends toward the introduction of the Common Test “Informatics I,” the status of ICT environment development and teacher deployment in high schools, and the improvement of legal system on digital textbooks.

2.1 The Courses of Study 2018/2019 and ICT environment development

(1) The Second Basic Plan for the Promotion of Education

The Courses of Study expanded the range of “Informatics” education in elementary and middle schools in in 2018 and in high school in 2019. The Courses of Study were based on the report published by the Central Council for Education in 2016. Therefore, this section reviews the background leading up to the 2016 report, and confirms what was recognized as educational issues in Japan at the time.

One of the most notable developments prior to the revision of the Courses of Study in 2018/2019 was the Second Basic Plan for the Promotion of Education, released in 2013. The Second Basic Plan was approved by the government cabinet between 2015 and 2018. The plan was prepared by MEXT to report to the Diet based on the “Basic Act on Education.” The first phase covered the period from 2008 to 2012. The Second Plan was also based on the report of the Central Council for Education, which MEXT consulted in 2011(MEXT, 2013).

The Second Plan recognized that Japan's environment was in a critical situation because of the following factors:

- ✓ Low birthrate and aging population
- ✓ Globalization
- ✓ Transformation of the employment environment
- ✓ Community and family transformation
- ✓ Reproduction and fixation of disparities
- ✓ Responding to global challenges

Although the first Basic Plan also stated that the requisite educational reform was still in its infancy, and the second plan set forth three principles of "self-reliance," "collaboration," and "creation" as the future direction of society, aiming to build a lifelong learning society to realize these principles. This presented a scenario for averting a crisis by increasing the productivity of society as a whole and securing social ties, thereby leading to individual self-realization, increasing the number of bearers in society, and improving inequality. The following four basic directions for educational administration were presented in the Second Plan:

- ✓ Cultivating the ability to survive in society
- ✓ Cultivating human resources to realize a leap into the future
- ✓ Building a safety net for learning
- ✓ Building bonds and creating vibrant communities

Among these, cultivating the ability to survive in society meant ensuring the development of the ability to learn, think, and act on one's own initiative, which is the foundation for lifelong learning. The Second Plan also included the promotion of cooperative and interactive learning through the use of ICT. In addition, the Second Basic Plan promoted the improvement of ICT environments in schools, such as the use of digital learning materials on a wide variety of terminals. (MEXT, 2013).

Although there was no strong awareness of the reform of Informatics education, there was an orientation toward education using ICT by improving the ICT environment in schools in the early 2010s.

(2) Report by the Central Council for Education in 2016 and "Informatics I"

In November 2014, MEXT issued "On the Standards for Curricula in Elementary and Secondary Education (Consultation)," consulting the Central Council for Education on how to make the Courses of Study suitable for the new era (MEXT, 2014). This consultation was in line with the Second Basic Plan. In response to this consultation, the Central Council for Education published a report in December 2016 (Central Council for Education, 2016).

The 2016 report proposed improvement measures, including the form of the Courses of Study, to enhance the "zest for life" that children acquire in anticipation of the society of 2030. The report is characterized by its proposal to introduce the perspective of active learning to realize independent,

interactive, and deeper learning. Although it does not use the term “curriculum overload,” it mentions the optimization of teachers' work and presented measures such as improving long working hours and utilizing external human resources. The report also emphasized the development of ICT environments and pointed out the need to improve teacher training.

The direction of the review of the content for each subject was also presented. As for the direction of “Informatics”, establishing “Information I” and “Information II” was recommended while reaffirming the importance of expanding the base of IT personnel, and acknowledging that there were issues with the study content at the time (Central Council for Education, 2016, pp. 206-208). The report also noted the need for programming and information security.

In line with this report, the Courses of Study were published in 2018; Based on it, “Informatics I” education in high schools commenced in 2022.

(3) The Courses of Study for High Schools in 2018 and “Informatics I”

Based on the aforementioned report, MEXT published the “Courses of Study for Senior High Schools” in March 2018. This is a large document with 608 pages, of which 485 pages contain information on acts and regulations, and the Courses of Study for junior high schools for reference. The distribution of pages in each chapter is as follows.

- Chapter 1 General provisions, pages 19 to 32

- Chapter 2: The Common Subjects for every school type, pages 33 to 198

- Chapter 3: Subjects offered mainly in specialized high schools, pages 199 to 474

As described above, Chapter 2 presents the Courses of Study for regular high school subjects. There were 11 Common Subjects: Japanese, geography and history, civics, mathematics, science, health and physical education, arts, foreign languages, home economics, information, science, and mathematics. Specialized departments, on the other hand, focus on specialized subjects. However, the 2018 Courses of Study did not include a proposal that a new subject, “Informatics I,” should be introduced in the Common Test.

In Japan, the percentage of students who went on to a regular high school course was approximately 60% in 1955, but this percentage increased to approximately 73% by 2020 (Counselor, Elementary and Secondary Education Bureau, MEXT, 2021). The percentage of high schools with a department specializing in “Informatics” increased to approximately 60% by 2020. In 2020, there were 26 high schools with a specialized course of “Informatics,” which is considerably fewer than the number of commercial (609) and industrial (526) high schools. High schools with specialized courses have historically focused on vocational education, and in 2020, slightly less than half of their graduates were employed immediately after graduation. The percentage of “Informatics” major students who go on to university or vocational school was quite high (72.6% in total), while the employment rate is 21.8%. Looking at the total number of regular and specialized courses, the percentage of high school graduates who got a job after graduation

declined to about 14.8%, as the number of students who went on to university or junior college increased (MEXT, n.a.-c).

In the Courses of Study 2018, Informatics consists of “Informatics I” and “Informatics II.” “Informatics I” is a new requisite course for regular high schools. According to the results of a survey conducted from September to October 2022 among high schools and junior high schools nationwide, 80% of the respondents answered that they do not offer “Informatics II” (including those who plan to), and many high schools offer only “Informatics I” as it is required.

As mentioned above, in Japan, there are only a few high schools with Informatics major in specialized high schools, and more than 70% of students go on to regular high schools and only some students would take “Informatics II.” Considering this, Appendix 1 provides a tentative English translation of the contents of the Courses of Study for “Informatics I” in Chapter 2: The Common Subjects for every school type. MEXT issued a “Commentary” on the Courses of Study, which was published in July 2018 (MEXT, 2018). This commentary is available for download from the MEXT website. It is 188 pages long and describes the aims of the study and instructional items in detail.

2.2 The newly introduced subject, “Informatics I,” in the Common Test

(1) Notice of the introduction of the Common Test “Informatics I” by MEXT in 2021

In Japan, MEXT has decided the subjects to be included in the Common Test. Based on the 2016 report of the Central Council for Education, Informatics education in high schools was revamped into “Informatics I” and “Informatics II.” Furthermore, MEXT officially announced in July 2021 that it would change the implementation outline of the 2025 Common Test to accommodate new study content based on the 2018 Courses of Study, adding “Informatics I” to the subjects to be tested (MEXT, 2021b). This advance notice was made to make the public aware of the changes as early as possible, as 2025 will be the first year in which the Common Test will be implemented, resulting in significant changes.

The 2025 Common Test will not only include the new “Informatics I,” but will also need to respond to the renewed content of many subjects to meet the Courses of Study 2018, which aims to realize independent, interactive, and deep learning. However, the introduction of essay-type questions that had been under consideration was postponed, and the conventional mark-sensing test will continue to be used in the Common Test. The introduction of a private English examination, which had been considered, was also postponed (ReseMom, 2021, July 30).

This “Informatics I” is the first new exam subject to be added to the Common Test in 21 years. In the 1990s and the early 2000s, foreign language subjects such as Chinese and Korean were added to the Common Test. Yoshida (2023) points out that the Japanese government's policy of promoting foreign-language diversification existed as a background for the addition of these foreign language subjects.

(2) The publication of "Informatics I" prototype test in December 2022.

In Japan, the National Center for University Entrance Examinations (NCCE), an independent administrative agency, prepares a university entrance examination for high school students called the Common Test. The Common Test is administered around mid-January each year. The number of examinees still exceeds 500,000 annually, although this number has declined slightly in recent years (NCCE, 2023a). The Common Test is a mark-sensing type that uses a paper-based question booklet and answer sheets.

"Informatics I" is scheduled to be administered in 2025. As this was the first examination of the new subject, the NCEE released several prototype tests for "Informatics I" in 2023 (NCEE, 2023b). At that time, explanatory materials were also released regarding the question policy in accordance with the "the Courses of Study" (NECC 2023c). In addition, as there are several programming languages used in textbooks (See Chapter 3), the NCEE has indicated its policy of using its own programming language that uses Japanese so that examinees can understand it, even while seeing it for the first time. (NCEE, 2023c, p. 12) .

This Japanese programming language is called DNCL, which is believed to be an abbreviation for Daigaku Nyushi Center Language. However, what it stands for has not yet been officially announced. The NCEE has published explanatory materials on the DNCL (NECC, 2022). Moreover, several programming platforms including "Nadeshiko-san" (https://nadesi.com/v3/doc/index.php) and "Donguri" (https://dolittle.eplang.jp/dncl) have been developed as programming environments for DNCL. Both can be programmed in Japanese.

A provisional English translation of a prototype of the Common Test subject "Informatics I" is included in this book as Appendix 2. The prototype contains 19 questions divided into four sections. Each question consists of several sub-questions. Section 1 includes questions on information society and basic information processing. Section 2 contains conversational style questions and focuses on QR codes. Section 2 also tests the data analysis and aggregation skills with questions on reading and interpreting graphs of the data presented and interpreting simulation results. Section 3 presents a programming question and uses DNCL. Section 4 is concerned with reading statistical data and box-and-whisker plots.

Although there are no real examinees for this prototype question, the difficulty levels seem to be standard, according to an analysis of a preparatory school for university entrance examinations. However, it has been pointed out that the 2025 Common Test may change the difficulty levels and question trends.

(3) Results of mock examinations conducted by prep schools in February 2023

Toshin, a preparatory school for university entrance examinations, conducted a mock exam for "Informatics I" in February 2023. A total of 10,780 first- and second-year high school students across Japan participated in the test. The test was similar in structure to the Common Test by the

NECC, with Section 3 being a programming question. The distribution of scores, average scores, and scoring rates for each section are displayed in Table 2 - 1.

Table 2 - 1 Results of the trial test by Toshin (a private preparatory school)

Section	Score	Average score	Average score percentage
1 Coverage of basic knowledge	30	15.4	51.30%
2 Information Design and Modeling	20	9.7	48.50%
3 Programming	25	7.7	30.80%
4 Data Application	25	13.2	52.80%
Total	100	46.1	46.10%

Source: Toshin (2023).

Table 2 - 1 shows that the percentage of correct answers for the programming section was only approximately 31%, which was lower than the percentage of correct answers for the other sections. The timing when the mock exam was conducted (November), suggests that there are issues in programming education in high schools, as it had been only less than a year since the study of "Informatics I" commenced in April 2022.

2.3 Status of GIGA School Initiative and ICT Environment in High Schools

(1) What is the GIGA School Initiative?

In conjunction with the aforementioned reforms, MEXT issued a notice on the Act on Promotion of Informatization of School Education, which aimed to promote the informatization of school education, and various measures were developed to improve the ICT environment after its enactment (MEXT, 2019c).

Specifically, MEXT announced the establishment of the "GIGA School Realization Promotion Headquarters" headed by it in 2019 to promote ICT environment development in schools. In the same year, it also announced that it would complete the development of ICT environments in all elementary, junior high, and high schools by the end of FY2023 (MEXT, 2019b). In addition, this initiative promoted the use of cloud computing and wireless broadband.

When the GIGA School Initiative was announced, the use of ICT in schools in Japan was weak compared to other OECD countries, according to the PISA 2018 survey. In addition, while around 40% of OECD countries used digital devices in the classroom for over 30 minutes per week, according to the PISA 2018 survey, Japan's use of digital devices was less than 20%, even in the most used science subject (MEXT, 2019a).

(2) Status of the ICT environment in high schools

In Japan, the ICT environment development for elementary and junior high schools has been completed, providing one PC per student through the government's supplementary budget through FY2020. However, the budget of FY2020 did not provide any budgetary provision for high schools; therefore, ICT environment development for high schools was completed later than that for elementary and junior high schools (G-Apps. jp, Feb, 15, 2022).

Under these circumstances, MEXT issued a notice in March 2021 indicating its policy to accelerate the development of ICT environments in high schools and requesting that high schools, local governments, and boards of education work together to develop such environments. When this notice was issued, only 42 local governments in Japan had a policy of deploying one PC per student. In addition, one-third of the local governments required parents to bear the cost of deployment, which varied based on municipality (Director-General of the Elementary and Secondary Education Bureau, MEXT, 2021). At the time of the issue of this notice, only 42 municipalities in Japan had a policy of deploying one PC per student in high schools. Additionally, one-third of the municipalities required parents to bear the cost of deployment, which differed between the municipalities.

Subsequently, through a supplementary budget for FY2021, subsidies became available even when parents were responsible for the costs (Director-General of the Elementary and Secondary Education Bureau, MEXT, December 27, 2021). The deployment of one PC per student has progressed regardless of whether the school or parents bear the cost of subsidies.

According to an annual survey conducted by the leading educational publisher Obunsha, since 2017, 76.4% of the 786 high schools in Japan have accomplished one PC per student environment as of January 2023. The percentage was 29.4% in 2021 and 50.1% in 2022, indicating rapid progress in the deployment of PCs (Obunsya, 2023, Feb, 28).

However, this means that when the instruction of “Informatics I” began in April 2022, all high schools had not yet completed the deployment of one PC per student. However, the deployment of one PC per student in the first year of high school would be completed by March 2023, and all grades are expected to complete the deployment by March 2025, according to MEXT (Division of School Support and Teaching Materials, Elementary and Secondary Education Bureau, February 2022).

Furthermore, MEXT released the “Plan for the Promotion of Informatization of School Education.” It was formulated to comprehensively and systematically promote the informatization of schools based on the “Act on the Promotion of Informatization of School Education” in 2019 (MEXT, 2022a). In addition to the development of ICT environments for schools and students, the plan also includes the promotion of schoolwork efficiency through the use of ICT, given the reality that teachers work long hours.

(3) Introduction of digital textbooks

In Japan, the Act for Partial Revision of the School Education Act, etc. in 2019 facilitated the use of "digital textbooks for learners" under certain conditions. There are several acts governing the use of digital textbooks, and to meet the relevant provisions, digital textbooks were required to record all the content of paper textbooks, and classes using digital textbooks were limited to one-half of the number of class hours in each subject area at that time (MEXT, 2019d).

However, although digital textbooks were institutionalized because of amendments to related acts and regulations, the 2020 study indicated that the schedule for their full-scale introduction would begin in FY2024. One of the reasons for this was that while 94% of the textbooks published were also digital textbooks for elementary school students and 95% for junior high school students, only 14.7% of municipalities had at least one school considering adopting them, indicating a low level of willingness to adopt them. This is because paper textbooks are provided free of charge to students at the government expense, but digital textbooks are not eligible for free provision; therefore, additional costs are incurred (Kozuchi, 2020).

Subsequently, a policy was issued to reduce the time spent using digital textbooks to half of the time limit in December 2020 (MEXT, 2020). The government has also announced that it will abolish restrictions on the use of digital textbooks in 2021. Furthermore, a demonstration project was implemented to distribute digital textbooks free of charge starting in FY2021. Through this demonstration project, digital textbooks were provided to approximately 890,000 students from 4,376 elementary and junior high schools nationwide. In addition, MEXT rapped up the status of cloud-based distribution of digital textbooks, its challenges, and solutions for them in their reports (MEXT, 2022c).

Chapter Summary

As outlined in this chapter, Japan expanded "Informatics" education in high schools in the 2010s. In response to the issues that arose after the introduction of "Informatics" education in the 2000s, the following measures were adopted: 1) making it compulsory, 2) introducing programming, 3) making it an independent subject for entrance examinations, and 4) improving the ICT environment. In addition, a system for digital textbooks has been developed, and education using "Informatics I" textbooks began in 2022.

However, we are beginning to observe challenges after 2022. The first is the slow speed of networks in schools. A high-bandwidth network environment is necessary for each student to use a PC and access educational materials and videos on the cloud. The percentage of schools with 1Gbps or higher was 41.6% (MEXT, August 2021). The percentage of schools with a network speed of 1 Gbps or higher was 41.6%. Therefore, the slowness of networks in schools has been recognized as an issue (ICT Education News, 2022, January 7).

A shortage of teachers for “Informatics I” has also been pointed out; as of May 2022, 16% of the teachers do not have a regular teaching license for “Informatics I” and 4.9% of the teachers have a temporary license. This means that 20% of teachers do not have regular licenses (Nihon Keizai Shimbun, November 8, 2022). Since the number of Informatics classes is as few as two per class per week, small schools in rural areas are in a situation where information teachers are simultaneously working in several schools. However, MEXT has been working to improve this situation by requesting that high schools systematically deploy Informatics teachers, and the number of temporarily licensed and unlicensed teachers has decreased since the survey as of 2020 (Fujii, 2022, November 8).

As described above, it is expected that “Informatics” education in high schools will be in full swing during the 2020s in Japan. However, not only are there already some issues to be addressed but the search for a new, more essential view of education and learning brought about using ICT has just begun. These movements are discussed in the final chapter.

Chapter 3 “Informatics I” Textbooks in the 2020s

Introduction Types and characteristics of “Informatics I” textbooks

Chapter 3 introduces the characteristics of “Informatics I” textbooks in Japan. There is a total of 12 different textbooks for “Informatics I” by six different publishers (Table 3 - 1). All textbooks are certified by MEXT (MEXT, 2021a).

Some publishers publish multiple textbooks with different difficulty levels, whereas others, such as Jikkyo Shuppan, publish different versions of only the programming language. Table 3 - 1 shows the programming languages used in each textbook for programming studies and their adoption share in Tokyo. Looking at the share of “Informatics I” textbook selection in Tokyo public high schools (164 schools) by publisher, Jikkyo Shuppan has the highest total share of 40.2%.

Table 3 - 1 Programming languages of each textbook and share of adoption in Tokyo.

Publisher (Total share)	Textbook title	Python	Java Script	VBA	Scratch	Share
Tokyo Shoseki (20.7%)	New Edition Informatics I (701)	✓			✓	14.6%
	Informatics I Step Forward!	✓	✓			6.1%
Jikkyo Shuppan (40.2%)	High School Informatics I: Python (703)	✓				10.4%
	High School Informatics I: JavaScript (704)		✓			1.2%
	Latest Informatics I (705)			✓		20.1%
	Illustrated Informatics I (706)				✓	8.5%
Kairyu-do (1.2%)	Practical Informatics Ⅰ (707)			✓		1.2%
Suken Shuppan (14.6%)	High School Informatics Ⅰ (708)	✓	✓	✓		9.1%
	Informatics Ⅰ Next (709)	✓	✓	✓		5.5%
Nihon Bunkyou Shuppan (19.5%)	Informatics Ⅰ (710)	✓	✓			11.0%
	Informatics Ⅰ- Illustrated (711)			✓		8.5%
	Informatics Ⅰ - Practice (712)					
Daiichi Gakusha (3.7%)	High School Informatics Ⅰ (713)	✓			✓	3.7%

Source: We Knowledge (2022), Tokyo Metropolitan Board of Education (2021b).

Although the 12 textbooks have one thing in common in that they are based on Courses of Study, their contents have unique characteristics. Some textbooks use illustrations extensively, whereas others are enriched with programming studies. There are also differences between the compilers and authors of the textbooks. Many publishers provide supplementary digital materials, each with unique features.

There are several analyses on the differences in textbook descriptions of "Informatics I" (Ogawa, 2022; Ide, 2022). The former summarizes the number of pages devoted to the items indicated in the Courses of Study in each textbook, and the latter summarizes the characteristics of each textbook in the programming learning section (Ogawa, 2022, pp. 13-15). According to Ogawa (2022), the number of items described differs from textbook to textbook, and some textbooks do not include any sub-items. Since all these textbooks have been approved by the MEXT, the differences in volume and items covered are acceptable.

In addition, each regional board of education prepares and releases research materials for high school textbooks to contribute to textbook selection in schools. According to the textbook survey data for "Informatics I," there are differences in the number of pages allocated to each textbook in the following four major categories: a) solving the problems of the information society, b) communication and information design, c) computers and programming, d) utilization of information communication networks and data. Table 3 - 2 shows the largest number of pages allocated by each textbook in the major items of "Informatics I." For example, Jikkyo Shuppan 705 devotes 53 pages (25.7% of the total pages) to c) Computers and Programming.

Table 3 - 2 "Informatics I" textbooks page allocation percentages for study items

Major items of "Informatics I" study content	Textbooks with high percentage of page allocation and percentage
a) Solving the problems of the information society	710 (26.4%) and 712 (30.7%),
b) Communication and information design	707 (28.0%), 708 (26.3%), 709 (29.0%), 711 (32.0%), and 713 (28.5%),
c) Computers and programming	701 (28.2%), 702 (30.9%), 703 (36.4%), 704 (36.4%), 705 (25.7%) and 703 (26.1%),
d) Utilization of information communication networks and data	-

Source: Tokyo Metropolitan Board of Education (2021a) and author's additions.

As shown in Tables 3 and 2, six textbooks devoted the most pages to c) computers and programming, followed by five textbooks that devoted the most pages to b) Communication and Information Design. Conversely, some textbooks allocated fewer pages to a) problem solving in the information society and d) information communication networks and data utilization. The tendency seen in the distribution of the number of pages is that the textbooks are divided into two categories: b) and c), and the next most important item is a) or d), which shows the characteristics

of each textbook (Table 3 - 3). The three textbooks with the least number of pages devoted to programming were 708 (18.8%), 709 (14.5%), and 713 (18.0%). These textbooks can be said to be relatively less challenging; however, they also have a lower adoption share. On the other hand, 701, which emphasizes programming, and 703 + 704 also have a certain share. 705, which has the largest market share, devotes the largest percentage of pages to b) communication and information design and the second largest number of pages to c) computers and programming.

Table 3 - 3 Classification of textbooks in order of number of pages in each textbook

Order of items by number of pages	Textbook number
c)-> b)-> a)-> d) Type	701, 702,
c)-> b)-> d)-> a) Type	703, 704,
c)-> a)-> b)-> d) Type	710
b)-> c)-> d)-> a) Type	705, 706, 711
a)-> c)-> d)-> b) Type	712
b)-> a)-> c)-> d) Type	707,
b)-> a)-> d)-> c) Type	708, 709, 713

Source: Tokyo Metropolitan Board of Education (2021a) and author's additions.

Thus, the characteristics of each textbook were analyzed from multiple perspectives. Furthermore, this chapter describes the characteristics of each textbook in terms of its contributors, digital teaching materials, use of illustrations, outline of teaching materials for teachers, programming studies, and terms found in the index. The four major publishers have published several "Informatics I" textbooks, differing in difficulty level and content.

Based on the above, textbooks from Tokyo Shoseki, Jikkyo Shuppan, Suken Shuppan, and Nihon Bunkyo Shuppan are described in detail in 3-1, 3-2, 3-3, and 3-4, respectively. Textbooks from publishers whose market share was less than 5% and who published only one type of textbook were omitted from the detailed analysis.

3.1 Tokyo Shoseki

(1) Tokyo Shoseki 701, "New Edition Informatics"[8]

Publisher	Tokyo Shoseki	
Language	Python	
Number of pages	203	

[8] Cover image source: https://ten.tokyo-shoseki.co.jp/text/hs/joho/

Contributors	(Team leaders) Akabori, Kanji, Professor Emeritus, Tokyo Institute of Technology) Higashihara, Yoshinori (Professor Emeritus, Shinshu University) Sakamoto, Akira (Vice President and Professor, Ochanomizu University) (Editors) 5 university members and 6 high school members (Editorial collaborators) 5 university members and 11 high school members	
Chapter title /page/ number of indexed items	Chapter 1: Solving Problems with Information (pp. 5-32) Chapter 2: Communicating Information (pp. 33-60) Chapter 3: Making Use of Computers (pp. 61-88) Chapter 4: Making Use of Data (pp. 89-116) Chapter 5: Activities and Proposals (pp. 117-149) Appendix (pp. 150-202) Number of indexed term: 301	
Web page	https://ten.tokyo-shoseki.co.jp/text/hs/joho/16650/	
Related Materials and Features	Related teaching materials and contents for teachers are provided on the above web page. The difference between “New Edition Informatics I” and “Informatics I Step Forward!” is that the latter emphasized on ease of understanding, and the response to the Common Test is not pushed to the forefront. (EduTown) The textbook related programming environment is called “EduTown Programming High School Information,” which can be logged into online. EduTown allows programming and execution in the browser. It also supports three textbook-compliant programming options, including API-based programming (assuming several hours of work each). (Draft syllabus, etc.)	

	The textbook publisher also provides draft syllabi and evaluation criteria for teachers. (Digital textbooks) Digital textbooks and workbooks for learners and digital books for instructors are also provided. These allow users to access related content with a click, without having to read a QR code. (Guidance note) For teachers, instructional materials that can be used in the classroom, such as instruction manuals, worksheets, syllabi, videos, and mark-sensing questions are provided.
Textbook Structure and Outline	(Composition and Goals) “The New Edition of Informatics I” is divided into five chapters and comes with about 50 pages of appendix. Chapters 1 through 4 are proofread with 10 items, appendix, my problem solving, end-of-chapter problems, and chapter summaries. Chapter 5 consists of 20 items, appendix, and “my problem solving”. Before each chapter, three pages are devoted at the beginning to explain basic computer operations, how to set up passwords, goals, and how to use the textbook. The catchphrase for the goals of “New Edition Informatics I” is “Become an Information Master,” and students are encouraged to skillfully use information and information equipment. “My Problem Solving” is a half-page column per item, with two items provided in each chapter. Activities and interviews with persons involved in the information are summarized. The questions at the end of the chapter mainly test the knowledge gained, and the summary is a short explanation of the key words studied. (Link to digital teaching materials) For each chapter, links to digital teaching materials accessible via QR code are provided under the name of D-Mark contents. 4 types of D-Mark contents are provided: 1) links to other subjects (PDF), 2) videos, 3) simulations, and 4) web pages. The list of D-Mark contents can also be accessed via QR code. A total of 37 types of D-Mark contents are available: 10 types in Chapter 1, 10 types in Chapter 2, 6 types in Chapter 3, 9 types in Chapter 4, and 2 types in Chapter 5. (Review materials) At the beginning of the textbook, an overview and links to other subjects are provided as D-marked content in the form of “Reflections on Middle

	School" (including content studied in elementary school). The reflective study materials are listed in a manner that corresponds to chapters 1 through 5 of "New Edition Informatics I," with 31 items in total. The look-back study content corresponding to each chapter is as follows. Chapter 1: "Junior High School – Technology and Home Economics," "Junior High School - Moral Education," "Junior High School - Health and Physical Education" Chapter 2: "Junior High School - Technology and Home Economics," "Junior High School - Science," "High School - Science and Human Life," "High School - Family Basics" Chapter 3: "Elementary School – Math," "Elementary School – Science," "Junior High School - Technology and Home Economics" Chapter 4: "Junior High School – Technology and l Home Economics," "Junior High School – Mathematics," "High School - Mathematics" Chapter 5: "High School and Mathematics" and "High School and Family Basics" In this way, the connection between what students have learned up to high school and the content of each chapter is made explicit, while review materials are also accessible to ensure that students can learn in a building-up fashion. (Programming) In Chapter 3, students learn programming; simple programming is described in both Python and Scratch. The longest programming is an 8-line code dice simulation, presented only in Python (p. 81). The "Hiragana Programming Handbook" at the end of the book also explains the basics of Python, JavaScript, spreadsheet macro language, Swift, Doolittle, Scratch, and microcontroller board programming in a few pages each. (Problem Solving) There are 20 items in Chapter 5, all of which are short (1-2 pages), and the content is designed for practical study of various items such as web page production, video production, databases, questionnaires, etc. There are no end-of-chapter questions in Chapter 5. (Appendix) Document processing software (image shows a Word screen), spreadsheet software (image shows an Excel screen), presentation software (image

	shows a PowerPoint screen), as well as e-mail writing, color, fonts, copyright and other laws, extensions, and prominent figures in the information field, a glossary and explanations of the binary system, etc. are provided.
Programming Problem Examples	The end-of-chapter questions in Chapters 1 through 4 are of two types: questions that test knowledge and those that use thinking skills. Of these, three questions are provided in Chapter 3 that test thinking skills related to programming.

(2) Tokyo Shoseki 702, "Informatics I Step Forward!"

Publisher	Tokyo Shoseki	
Language	Python	
Number of pages	230	
Contributors	(Team leaders) Akabori, Kanji, Professor Emeritus, Tokyo Institute of Technology) Higashihara, Yoshinori (Professor Emeritus, Shinshu University) Sakamoto, Akira (Vice President and Professor, Ochanomizu University) (Editors) 5 university members and 5 high school members (Editorial collaborators) 6 university members and 11 high school members	
Chapter title/ page/ number of indexed items	Chapter 1: Information Society (pp. 2-30) Chapter 2: Information Design (pp. 31-69) Chapter 3 Programming (pp. 70-102) Chapter 4: Networking (pp. 103-136) Chapter 5 Problem Solving (pp. 137-169) Appendix (pp. 170-215) Indexed Terms: 575	
Web page	https://ten.tokyo-shoseki.co.jp/text/hs/joho/16651/	
Related Materials and Features	The same digital textbooks and contents for instructors as "New Edition Informatics I" are provided. The difference between "Informatics I: Step Forward!" and "New Edition Informatics I" is that the former makes the content of each item richer and the response to the Common Test is strengthened.	

Textbook Structure and Overview	(Composition and Goals) “Informatics I Step Forward!” is divided into five chapters and includes 45 pages of appendix. Chapter 1 has 11 items, Chapter 2 has 14 items, Chapter 3 has 12 items, Chapter 4 has 12 items, and Chapter 5 has 21 items. In addition, Chapters 1 through 4 come with the items my problem solving, end-of-chapter problems, and chapter summaries. The chapter summary is an explanation of key words, and my problem solving is a half-page introduction to one person involved in the information field, like “New Edition Informatics I.” (Link to digital teaching materials) Under the name of D-Mark contents, links to digital educational materials accessible via QR code are provided. 4 types of D-Mark contents are available: 1) links to other subjects (PDF), 2) videos, 3) simulations, and 4) web pages. The list of D-Mark contents can also be accessed via QR code. In all, a total of 39 types of D-Mark content are available. (Review materials) From the materials at the end of the book, an overview and links to other subjects are provided as D-marked content as “Reflections on Middle School” which is the same as “New Edition Informatics I.” (Programming) In Chapter 3, students learn how to program; simple programming is described in both Python and JavaScript. The longest programming is a dice simulation, presented only in Python. (Problem Solving) There are 21 items in Chapter 5, all of which are short (1-2 pages), and the content is designed for the practical study of diverse items such as web page production, video production, databases, questionnaires, birthday simulations, etc. Note that there are no end-of-chapter questions in Chapter 5. (Appendix) The appendix is the same as “New Edition Informatics I.”
Programming Problem Examples	The end-of-chapter questions in Chapters 1 through 4 are of two types: questions that test knowledge and questions that use thinking skills. Of these, four questions are provided in Chapter 3 that test thinking skills related to programming, and there are no questions that test knowledge.

3.2 Jikkyo Shuppan

(1) Jikkyo Shuppan 703 and 704, "High School Informatics I" [9]

Publisher	Jikkyo Shuppan
Language	Python (703), JavaScript (704)
Number of pages	206
Contributors	(Editors and authors) Hagiya, Masami (Professor, The University of Tokyo) (Editorial supervision) Okamoto, Toshio (Professor Emeritus, The University of Electro-Communications) (Editor) Watanabe, Michiko (Professor, Graduate School of Keio University) (Authors) 3 university members and 4 high school members (Cooperators) 8 high school members
Chapter title/ Page (703) / number of indexed items	Chapter 1: Information Society (pp. 3-20) Chapter 2: Information Design (pp. 21-42) Chapter 3: Digital (pp. 43-68) Chapter 4 Network (pp. 69-94) Chapter 5 Problem Solving (pp. 95-128) Chapter 6 Programming (pp. 129-174) Answers to End-of-Chapter Questions, Outline of Copyright Law, Index, etc. (pp. 175-191) Number of indexed items: 672 (703) / 692 (704)
Web page	https://www.jikkyo.co.jp/book/detail/22023322 (703/704)

[9] Cover image source: https://www.jikkyo.co.jp/book/detail/22023322

Related Materials and Features	Digital contents for instructors that can be used in schools include lesson slides in PowerPoint format and data on marked periodic examination questions (compatible with Google Form). In addition, digital data for syllabi and assessment items are also available. Digital content for instructors comes with a license when purchasing instructional materials and can be logged in and used from the publisher's website. Digital data that can be distributed to students is also available, depending on the learning item.
Textbook Structure and Overview	(Composition and Goals) Informatics I" is divided into six chapters, and comes with answers to end-of-chapter question, an index, etc. Chapters 1 through 6 are numbered consecutively, with a total of 35 items. However, Advance items that are not included in the item numbers are inserted as necessary, and 11 items of Advance content are included in total. Chapters 1 and 4 contain no Advanced items, Chapters 2 and 3 contain one item each, Chapter 5 contains four items, and Chapter 6 contains five. Chapters 1 through 6 each contain one page of end-of-chapter questions, and Chapter 6 contains seven pages of comprehensive questions. In this textbook, the emphasis is on problem solving in the information society and on computational thinking. It also encourages students to learn how computational thinking can make everyday life more enjoyable and fulfilling. (Link to digital teaching materials) The "QR" mark provides links to digital learning materials. In total, there are 39 digital learning materials accessible from the "QR" mark. Of these, eight are links to NHK for School content. Eight of the links are to laws such as the Act on the Protection of Personal Information, which takes users to the e-Gov site. Although most content is identical, each textbook has a different access point from the QR code: https://www.jikkyo.co.jp/d1/01/jo/22jo4 from 703 and https://www.jikkyo.co.jp/d1/01/jo/22jo1 from 704. (Programming) In both 703 and 704, students will learn programming in Chapter 6. Although the language is different, the learning content is identical. In the Advance section, students learn object-oriented programming, program design

	techniques, open data utilization, dynamic simulation with plug-ins, and measurement, control, and programming. The number of lines of programming explained in the textbook is longer, around 20 lines; Python is often a few lines shorter, but the learning content is the same. Advance sections include a set of examples, discussions, sample solutions, and problems. (Problem Solving) Characteristically, Chapter 2, Information Design, has a detailed explanation of HTML and CSS and devotes 9 pages to this subject. In Chapter 5, Problem Solving, there are specific case studies, and the emphasis is on acquiring statistical and data analysis methods. (Appendix) The appendix includes answers to end-of-chapter questions, comprehensive questions, an overview of copyright law, an index, etc. The volume is approximately 25 pages in length.
Programming Problem Examples	The end-of-chapter questions in Chapter 6 are designed to test the student's mastery of basic programming content. The comprehensive questions are of a high degree of difficulty, and no sample answers are provided.

(2) Jikkyo Shuppan 705, "Latest Informatics I"

Publisher	Jikkyo Shuppan
Language	VBA
Number of pages	206
Contributors	(Editors and authors) Hagiya, Masami (Professor, The University of Tokyo) (Editorial supervision) Okamoto, Toshio (Professor Emeritus, The University of Electro-Communications) (Editor) Watanabe, Michiko (Professor, Graduate School of Keio University)

	(Authors) 4 university members and 4 high school members (Cooperation) 8 high school members	
Chapter title /page/ number of indexed items	Chapter 1: The Information Society and Us (pp. 3-24) Chapter 2: Media and Design (pp. 25-60) Chapter 3: Systems and Digitization (pp. 61-90) Chapter 4: Networks and Security (pp. 91-114) Chapter 5: Problem Solving and Methods (pp. 115-160) Chapter 6: Algorithms and Programming (pp. 161-183) Appendix (pp. 184-191) Number of indexed items: 658	
Web page	https://www.jikkyo.co.jp/book/detail/22023122	
Related Materials and Features	The contents are similar to those of 703 and 704 of Jikkyo Shuppan.	
Textbook Structure and Overview	(Composition and Objectives) “Latest Informatics I” has six chapters with accompanying end-of-chapter questions. Each chapter consists of sections and subsections, with a total of 16 sections and 57 subsections. Each section has example questions and answers that are integrated with the study content. In the “Introduction,” the same goals of 703 and 704 of the Jikkyo Press are presented, indicating the need for computational thinking and the enjoyment and enrichment of daily life through it. (Link to digital teaching materials) As with Jikkyo Shuppan's 703/704, digital teaching materials accessible via QR code are available. Digital materials for the 705 are https://www.jikkyo.co.jp/d1/01/jo/22jo2. (Programming) In Chapter 6, students will learn algorithms and programming. Chapter 6 is 23 pages short and teaches programming using VBA in Excel. Ten programming examples using VBA are provided, covering the basics and applications. While	

	some programs have less than 10 lines, the longest program is a bicubic search to find the number of inventories. The longest program is 26 lines. (Problem Solving) One of the features of the textbook is the large amount of information on problem solving and its methods in Chapter 5, which covers 45 pages, about twice the amount of Chapter 6. After showing the process from problem identification to solution, detailed explanations are given on the use of data, including the basics of using Excel, graphing, and statistical analysis. Modeling and simulation methods using Excel are also explained. (Security) Chapter 4 includes security in the chapter title with right explanation of information security. (Appendix) The volume includes seven pages of end-of-chapter problem answers, a copyright overview, and an index.
Programming Problem Examples	The end-of-chapter questions in Chapter 6 test the student's mastery of basic programming content, and 12 questions are provided.

(3) Jikkyo Shuppan 706, "Illustrated Informatics I"

Publisher	Jikkyo Shuppan
Language	Scratch
Number of pages	184
Contributors	(Editors and authors) Hagiya, Masami (Professor, The University of Tokyo) (Editorial supervision) Okamoto, Toshio (Professor Emeritus, The University of Electro-Communications) (Editor) Watanabe, Michiko (Professor, Graduate School of Keio University)

	(Authors) 2 university members and 2 high school members, etc. (Cooperation) 7 high school members	
Chapter title /page/ number of indexed items	Introduction: The Information Society and Us (pp. 2-11) Chapter 1: Information Society and Problem Solving (pp. 12-39) Chapter 2: Communication and Information Design (pp. 40-65) Chapter 3: Information and Computers (pp. 66-95) Chapter 4: Algorithms and Programs (pp. 96-115) Chapter 5: Modeling and Data Application (pp. 116-141) Chapter 6: Networks and Information Systems (pp. 142-171) Appendix (pp. 172-175) Number of indexed items: 364	
Web page	https://www.jikkyo.co.jp/book/detail/22023222	
Related Materials and Features	The contents are similar to those of 703 and 704 of Jikkyo Shuppan.	
Textbook Structure and Overview	(Composition and Objectives) “Illustrated Informatics I” has six chapters, accompanied by a summary and end-of-chapter questions. Each chapter is organized in sections and subsections, with an introduction, 19 sections, and 58 items in total. Chapters 1 through 6 provide practical exercises that are integrated with the study content. The textbook is characterized by many illustrations and a small amount of text. Another feature is that the practical training shows actual work procedures using the software. In the “Introduction,” the same goals of 703and 704 of the Jikkyo Shuppan are presented, indicating the need for computational thinking and the enjoyment and enrichment of daily life through it. (Link to digital teaching materials) As with Jikkyo Shuppan's 703/704, digital teaching materials accessible via QR code are available. Digital materials for the 706 are https://www.jikkyo.co.jp/d1/01/jo/22jo3.	

	(Programming) In Chapter 4, students learn algorithms and programming. Chapter 4 is short (20 pages) using Scratch. Programming such as graphing, sorting, rock-paper-scissors games, etc. are explained. (Information Society and Problem Solving) One feature of this textbook is that more pages are devoted to chapters other than programming in Chapter 4. However, there are few references to laws, and the emphasis is on clarity through illustrations. (Appendix) The volume includes four pages of end-of-chapter problem answers and an index.
Programming Problem Examples	The end-of-chapter questions in Chapter 4 test the student's mastery of basic programming content, and five questions are provided.

3.3 Suken Shuppan

(1) Suken Shuppan 708, "High School Informatics I"[10]

Publisher	Suken Shuppan	
Language	Python, JavaScript, VBA	
Number of pages	208	
Contributors	(Authors) Sakamura, Ken (Professor, Toyo University) 5 university members and 7high school members, etc. (Editorial cooperation) 17 high school members, etc., and 1 lawyer	
Chapter title /page/ number of	Part 1: Problem Solving in the Information Society (pp. 10-47) Part 2: Communication and Information Design (pp. 48-89) Part 3: Computers and Programming (pp. 90-121) Part 4: Information Networks and Data Application (pp. 122-159)	

[10] Cover image source: https://www.chart.co.jp/kyokasho/22kou/joho/kou/

indexed items	Practical training and general questions at the end of the book (pp. 160-179) Appendix (pp. 180-207) Number of indexed items: 383
Web page	https://www.chart.co.jp/kyokasho/22kou/joho/kou/
Related Materials and Features	In addition to QR content linked to textbooks, teaching materials include instructional textbooks, data and materials on DVDs, instructional videos accessible online, tests in Google Forms, supplementary materials with questions corresponding to the Common Test, digital textbooks, and syllabus data.
Textbook Structure and Overview	(Composition and Goals) "High School Informatics I" has four parts: Part 1 has three chapters, Part 2 has four chapters, Part 3 has three chapters, and Part 4 has three chapters, for a total of 13 chapters. The book comes with end-of-book exercises and comprehensive questions. Within each chapter, there are subsections of the alphabet. In addition, information on occupations related to the subject is also included in consideration of career education. Learning activities such as exercises, and practical training are presented where appropriate. The content is more detailed than "Informatics I Next" from the same publisher. At the beginning, Ken Sakamura explains why we study information. He points out the need to make society more sophisticated and the need for the efficient usage of information and communication technology to solve challenges in Japan. The goal is expressed in the hope that students will acquire the fundamentals of Informatics and can utilize programming in their work and daily lives and change society. (Link to digital teaching materials) A digital educational material, "LINK," accessible via QR code. LINK" can be accessed at https://www.chart.co.jp/qr/22i01/. LINK" provides links to "NHK for School" video clips and many other external contents, as well as a confirmation test that can be answered online. In addition, a JavaScript program can be executed from the linked web page for Chapter 2 of Part 3Programming. (Programming) In Chapter 2 of Part 3, students learn programming. After an explanation of algorithms and programming languages, programming methods are presented using multiple languages. It is shown how the idea of algorithms is programmed in each language. Modeling and simulation in Volume 3, Chapter 3, also provides examples of programming.

	(Problem Solving in the Information Society) This textbook is characterized by the fact that the explanations in Chapter 3 of Part 1, "Solving Problems in the Information Society," are based on everyday life and are designed to provide skills to safely use information technology. Detailed explanations of topics such as artificial intelligence and digital transformation are also included. (Appendix) End-of-book materials include information on software usage, copyrights, report writing, programming materials, and HTML-related information.
Programming Problem Examples	Programming and simulation questions are included in the end-of-edition questions in Part 3.

(2) Suken Shuppan 709, "Informatics I Next" [11]

Publisher	Suken Shuppan	
Language	Python, JavaScript, VBA	
Number of pages	184	
Contributors	(Authors) Sakamura, Ken (Professor, Toyo University) 5 persons from universities 6 high school members, etc. (Editorial cooperation) 8 high school members, etc., 1 lawyer	
Chapter title and page/ number of indexed items	Part 1: Problem Solving in the Information Society (pp. 6-47) Part 2: Communication and Information Design (pp. 48-93) Part 3: Computers and Programming (pp. 94-119) Part 4: Information Networks and Data Application (pp. 120-155) Appendix (pp. 156-184) Number of indexed items: 427	
Web page	https://www.chart.co.jp/kyokasho/22kou/joho/next/	

[11] Cover image source: https://www.chart.co.jp/kyokasho/22kou/joho/next/

Related Materials and Features	The contents are similar to those of 703 and 704 of Jikkyo Shuppan.
Textbook Structure and Overview	(Composition and Objectives) More than half of the textbook consists of diagrams and illustrations, emphasizing clarity and a wealth of practical exercises. The structure is the same as that of "Informatics I" (708) from the same publisher, but the number of pages differs slightly, and the practical exercises at the end of the book and comprehensive problems are not included. In all, 51 items and 16 exercises are provided. (Link to digital teaching materials) A digital educational material, "LINK," accessible via QR code, is available. LINK can be accessed at https://www.chart.co.jp/qr/22i02/. The content is almost the same as "Informatics I" (708) from the same publisher, but the programming section is less challenging and contains fewer items than 708. (Programming) In the second chapter of Volume 3, students learn programming. After an explanation of algorithms and programming languages, programming methods are presented in several programming languages, with fewer lines of programming than in 708. In addition, the end-of-edition problems do not include programming problems. (Information Society and Problem Solving) One feature of this textbook is that more pages are devoted to chapters other than programming in Chapter 4. However, there are few references to laws, and the emphasis is on clarity through illustrations; there are no explanations of topics such as artificial intelligence or digital transformation, which were included in 708. (Appendix) The material at the end of the book is identical to that in Informatics I (708) from the same publisher.

3.4 Nippon Bunkyo Shuppan

(1) Nippon Bunkyo Shuppan 710, "Informatics I"[12]

Publisher	Nihon Bunkyo Shuppan	
Language	Python, JavaScript	
Number of pages	208	
Contributors	(Editorial supervision) Kurokami, Haruo (Professor, Kansai University) Hotta, Tatsuya (Professor, Tohoku University) Murai, Jun (Professor, Keio University) (Editors and authors) 12 university members, 23 high school members, and 3 others (Editorial assistance) 1 university member, 16 high school members, and 1 other person	
Chapter title and page/ number of indexed items	Introduction: We Live in an Information Society (pp.6-15) Chapter 1: Problem Solving in the Information Society (pp. 16-65) Chapter 2: Communication and Information Design (pp. 66-117) Chapter 3: Computers and Programming (pp. 118-167) Chapter 4: Information and Communication Networks and Data Application (pp. 168-209) End-of-Volume Practice and End-of-Volume Problems (pp. 210-215) Appendix (pp. 216-223) Number of indexed items: 451	
Web page	https://www.nichibun-g.co.jp/textbooks/joho/2022_joho01_1/	
Related Materials and Features	In addition to QR contents linked to textbooks, examples of annual teaching plans, draft syllabi, examples of evaluation criteria, and teaching materials (commentaries, digital data) are provided.	
Textbook Structure	(Composition and Objectives) This textbook has five chapters, including an introduction. It comes with end-of-book questions and end-of-book materials. Each chapter contains sections	

[12] Cover image source: https://www.nichibun-g.co.jp/textbooks/joho/2022_joho01_1/

and Overview	and subsections, which together comprise 56 items. One of the features of the book is that the introduction includes an explanation of the significance of studying information and a review of the information up to junior high school. In the introduction, the author states that the significance of studying information is the need to use information technology to discover and solve problems. It also conveys that we have a responsibility to strive to move closer to a desirable society by using information and information technology. The introductory chapter also includes a pre-study skill check and an overview of each chapter to ensure a smooth start to learning. Chapters 1 through 4 provide skill acquisition procedures called “Techniques” and end-of-chapter questions. A total of 17 “Techniques” are included. They include website development and JavaScript, and the book is well-developed in information design. (Link to digital teaching materials) Digital resources are accessible via QR code at https://www21.nichibun-g.co.jp/k-dc/joho/01/. The “Textbook QR Content” includes many video explanations, answers to end-of-chapter questions, and a glossary. (Programming) In Chapter 3, students learn programming. After explaining the components of programing, the chapter covers programming as part of application development. It also shows how to program a simulation using a model. In addition, four pages are allocated to explaining the basics of Python. (Problem Solving in the Information Society) It covers the characteristics of the media, the importance of law, and the changes in life and society resulting from the development of information technology. The book also explains how to organize problems and formulate hypotheses and provides instructions on how to use various types of software. (Appendix) Although not included in the number of pages of this volume, there are approximately 10 pages of material at the beginning and end of the book, respectively. The opening material covers advanced technology, graphical representation, information design, presentation techniques, report writing, and e-mail etiquette, while the closing material including color samples, HTML and CSS basics, JavaScript basics, Python basics, the history of computers and smartphones, keyboard layout, etc. are included in the book.

Programming Problem Examples	There are no programming questions in the end-of-chapter questions, but programming questions are included in the end-of-book questions.

(2) Nippon Bunkyo Shuppan 711 and 712, "Informatics I, Illustrated and Practice"[13]

Publisher	Nihon Bunkyo Shuppan	 
Language	VBA	
Number of pages	128 (Illustrated)/101 (Practice)	
Contributors	(Supervisors) Kurokami, Haruo (Professor, Kansai University) Hotta, Tatsuya (Professor, Tohoku University) Murai, Jun (Professor, Keio University) (Editors and Authors) 11 university members, 23 high school members and 1 other person (Editorial assistance) 15 high school members and 1 other person	
Chapter title and page/ number of indexed items	(Illustration) Chapter 1: The Information Society and Us (pp. 4-21) Chapter 2: Communication and Information Design (pp. 22-61) Chapter 3: Computers and Programming (pp. 62-91) Chapter 4: Information and Communication Networks and Data Application (pp. 92-117) Index (pp. 118-119)	

[13] Cover image source: https://www.nichibun-g.co.jp/textbooks/joho/2022_joho01_2/textbook/

	Number of indexed items: 298
Web page	https://www.nichibun-g.co.jp/textbooks/joho/2022_joho01_2/textbook/
Related Materials and Features	In addition to QR content linked to textbooks, teaching materials include instructional textbooks, data and materials on DVDs, instructional videos accessible online, tests in Google Forms, supplementary materials with questions corresponding to the Common Test, digital textbooks, and syllabus data.
Textbook Structure and Overview	(Composition and Goals) This textbook has five chapters, including an introduction. It comes with end-of-book questions and end-of-book materials. One of the features of the textbook is that the introductory chapter includes an explanation of the significance of learning information and a review of the information up to junior high school level. Chapters 1 through 4 provide skill acquisition procedures called "Techniques" and end-of-chapter questions. The "Introduction," under the name of Ken Sakamura, includes a one-page explanation of why we study information as is in 710. (Link to digital teaching materials) The same as 210 digital resources are accessible via QR code at https://www21.nichibun-g.co.jp/k-dc/joho/01/. The "Textbook QR Content" includes many video explanations, answers to end-of-chapter questions, and a glossary. (Programming) In Chapter 2 of Volume 3, students will learn programming. After an explanation of algorithms and programming languages, programming methods are presented using multiple languages. The following shows how the idea of algorithms is programmed in each language. Modeling and simulation in Volume 3, Chapter 3, also provides programming examples. (Problem Solving in the Information Society) The book is characterized by the explanations in Chapter 3 of Part 1, "Solving Problems in the Information Society," that are based on everyday life and are designed to provide skills to safely use information technology. Detailed explanations of topics such as artificial intelligence and digital transformation are also included. (Appendix)

	End-of-book materials include information on software usage, copyrights, report writing, programming materials, and HTML-related information.
Programming problem	Programming and simulation questions are included in the end-of-edition questions in Part 3.

Chapter Summary: Expansion of Programming Education in "Informatics I" Textbooks

A variety of textbooks are published in Japan because high school principals and district boards of education have the authority to select textbooks (MEXT, n.a.-a). Moreover, high schools select textbooks annually according to their students' needs and academic abilities (MEXT, n.a.-b). Textbook authors and publishers have a certain degree of freedom to set the level of detail and difficulty in explaining the learning items in each textbook. Textbook publishers strive to formulate textbooks and related teaching materials that meet schools' educational needs. Consequently, in Japan, while textbooks cover the learning content described in MEXT's Courses of Study, they have distinctive characteristics.

Both textbooks are written and supervised by leading and top researchers and educators and are designed not only to be accurate and reliable, but also to attract learners' interest and attention. Consequently, the "Informatics I" textbooks are attracting attention even from working adults who have not studied the subject. Furthermore, the "Informatics I" textbooks are not limited to the paper version of the textbook that conforms to the Courses of Study but also come with digital versions of the textbook, a programming environment, digital contents and supplementary materials for students, an instructional guidebook for teachers, downloadable syllabi and evaluation sheets, and a variety of other materials.

Thus, the Japanese government's initiatives have strengthened programming learning by improving the ICT environment and institutional setup for the subject of "Informatics I" and by the revision of the Courses of Study. At that time, a network environment in schools, a PC environment for each student, and digital learning materials on the cloud were prepared, and the development of a learning environment without significant differences across the country progressed.

Final Chapter Summary and Prospects for Reform of “Informatics I” in Japan

1. Significance: Linkage between programming and social problem solving

As explained in the previous chapter, practical programming education was provided only in specialized high schools in the past. A reason is that it was too early in Japan to make programming education compulsory because of limited access to ICT environment and the necessity to train teachers and prepare textbooks for programming education. In addition, programming education was implemented as part of vocational education in technical high schools, and in the Informatics courses that were introduced in 2003. It can be said that the roles were divided between regular high schools and vocational high schools. The former acquired knowledge and educational content, whereas the latter acquired practical content, including programming.

In 2022, programming will become mandatory in high schools in Japan in response to the rapid progress of the information society and the demand for more practical and realistic computer science knowledge and skills. Simultaneously, the university entrance examination system was also reformed, and “Informatics I” was introduced as an independent subject for the Common Test. This has increased the importance of Informatics I in the high school curriculum, and it can be considered a countermeasure to the problems faced by uneducated students in the past.

Many high schools in the past chose Informatics-related subjects that did not include programming studies. However, Table Final shows that “Informatics I” now consists of a mandatory section on computers and programming, which covers most of the topics studied in the European Report.

Table Final Japanese subject “Informatics I” and study items in the European report

Study items of “Informatics I” in Japan	Study Items of the European Report	Coverage of items in the past textbooks in Japan
a) Solving the problems of the information society	9) Awareness and empowerment 10) Safety and security	“Informatics A” “Informatics C” “Information and Society” “Science of Information”
b) Communication and information design	6) People-system interfaces 7) Design and development	“Informatics A” “Informatics C” “Information and Society” “Science of Information”
c) Computers and programming	2) Algorithms 3) Programming 4) Computing systems	“Informatics B” “Science of Information” (Item 4 in the European report was covered in “Informatics A” and “Information and Society”)
d) Utilization of information communication networks and data	1) Data and information 5) Networks	“Informatics A” “Informatics C” “Information and Society”

	8) Modelling and simulation	"Science of Information"

Source: Compiled by the author from various sources.

As shown in Table Final - 1, a) Problem-solving in the information society is classified as a learning item corresponding to 9) Awareness and empowerment and 10) Safety and security in the European Report, but strictly speaking, there is a difference between these two. In the European Report, "Awareness" refers to learning about the impact of computing on society, and "Empowerment" refers to the overall enhancement of individual capabilities and social impact brought about by the use of computers.

On the other hand, "Problem Solving in the Information Society" in Japan focuses on "activities to discover and solve problems in the information society" and cultivating the ability to use information and information technology appropriately and effectively, as stated in the Courses of Study (See Appendix 1). Each textbook in Japan also includes explanations of the flow of problem solving and the conception method, and in many cases, programming learning is linked to the solution of social issues.

2. The remaining challenge: the shift to 21st-century style education

While "Informatics" related subjects have been reformed and expanded in Japan as outlined above, there are some remaining issues. The first was curriculum overload (CO). This is a situation in which both teachers and students are burdened by the increased learning content (e.g., recent additional English and Informatics content) and the additional time required to develop comprehensive academic skills (e.g., "inquiry-based learning").

Regarding this situation, MEXT stated that it was important to make maximum use of ICT in education based on the 2018 Courses of Study to enhance "individually optimized learning" and "collaborative learning" in an integrated manner. It also indicated a direction for improving curriculum management to realize "independent, interactive, and deep learning" (Elementary and Secondary Education Bureau, MEXT, 2021).

In Japan, traditional curriculum management is based on the mastery-based/age-based approach, whereby specific ages are assigned to specific grades and the content to be studied for each grade was indicated in the Courses of Study. However, in the 2021 document, the MEXT aimed to achieve both "individually optimized learning" according to the diversity of students and "collaborative learning" that fosters social skills while recognizing that the concept of mastery-based and process-based learning, in which students advance to a higher level process by mastering what they learn; this has become possible because of the use of ICT Direction (Curriculum Division, Elementary and Secondary Education Bureau, MEXT, 2021).

Examining the above changes from the three perspectives of 1) educational content, 2) educational objectives, and 3) educational style shown below, Japan is trying to shift not only the introduction

of “Informatics I” but also the entire new educational approach in response to the 21st-century information society.

1) Educational content: From Information Society “Informatics” to more “Computer Science” for connection to the university
2) Educational Objective: From “Specialized Subjects” as a vocational education to “General Subjects” as citizen education
3) Educational style: From “Education in the industrial society of the 19th century” to “Education in the information society of the 21st century”

First, regarding the educational content of 1), MEXT emphasized learning items in computer science that went beyond IT equipment literacy in the 2020s. In addition, computer science-related items such as programming are now included in regular education courses rather than vocational education courses and are now considered essential for the education of citizens. Furthermore, the educational style described in 3) is in the process of being transformed from the 19th century education in which students in the same grade studied textbooks all together in the same classroom to the 21st century style of “individually optimized and collaborative learning.”

3. ICT Utilization: EdTech and the expanded use of digital educational materials

In Japan, ICT-based learning has expanded beyond school education. An example is “Study Supli,” a digital learning material for elementary, junior high, and high school students provided by Recruit Co. The service began in 2012 with the distribution of preparatory courses for university entrance examinations. The lessons delivered have been improved annually using artificial intelligence (AI) based on course history data and other personal learning data.

Some schools have introduced the application as a learning material, allowing students to select and take various video lessons according to their level of understanding and learning goals. The monthly fee increased to approximately JPY 2, 000; however, the number of users continues to increase. As of March 2022, the application had 1.57 million users, bringing the total number of members to over 13 million (Kuriki, 2022, Sep. 8). In April 2023, a new course for high school students, “Information Fundamentals I,” commenced (Children and IT, 2023, April 12).

Not limited to the services mentioned above, the acceptance of EdTech is also expanding in Japan, with an increasing number of services utilizing new technologies such as ICT and AI, which contribute to realizing individually optimized learning.

4. Prospects: Balancing individually optimized learning and collaborative learning

In Japan, discussions are underway on the next Courses of Study, which are expected to be released by 2027. In March 2023, the Central Council for Education released its “Report on the Next Basic Plan for the Promotion of Education” (Central Council for Education, 2023). Subsequently, in June 2023, the cabinet approved the fourth “Basic Plan for the Promotion of Education” (2023-2027)

(Cabinet Decision, 2023). The plan was based on the following two points: The Basic Plan establishes the following two basic policies for education policy (pp.9-10.).

- ✓ Foster creators of a sustainable society with a view to 2040 and beyond
- ✓ Improve wellbeing rooted in Japanese society

In conjunction with this, the report also indicates "a direction that corresponds to the integrated enhancement of individually optimized learning and cooperative learning. It states that an ICT environment that has dramatically improved through the GIGA school concept should be utilized to create a better educational environment that meets the needs of each individual student. The next Courses of Study are expected to be released in 2027, and their basic direction will be based on the Fourth Basic Plan for the Promotion of Education.

The above direction is not limited to the field of education policy but was also included in the "Policy Package on Education and Human Resource Development for the Realization of Society 5.0" compiled by the Council for Science, Technology, and Innovation in the Cabinet Office in 2022 (Council for Science, Technology, and Innovation, 2022). This package includes several measures to promote the development of education and human resources. In line with this package, back data on the need for individually optimized learning were also published, revealing the reality of students with diverse backgrounds and academic abilities.

As described above, reforms in the Japanese subject "Informatics I" are expected to continue after the introduction of "Informatics I" in 2022. Although the Common Test for "Informatics I" is not computer-based and does not include a practical programming test, it is expected that the testing and evaluation methods will change as programming practice in the classroom is conducted on one PC for each student.

5. Summary and future research agenda: toward international mutual exchange

This book provides an overview of the transformation of the subject "Informatics" in Japan from the 2000s to the 2020s. The changes over the past 20 years can be summarized as follows:

(Educational content reform: the Courses of Study 2018)

- ✓ "Informatics I" became a mandatory course in regular high schools from 2022.
- ✓ Programming is mandatory learning in "Informatics I."
- ✓ "Informatics I" became an independent subject in the Common Test from 2025.

(ICT environment development in schools: GIGA school initiative)

- ✓ The deployment of one PC per student in high schools will be complete by 2025.
- ✓ The school's wireless broadband network becomes faster and wireless.
- ✓ The use of cloud services and ICT in school administration is progressing.

(Institutional development: legal reforms and the formulation of 5-year plans.

- ✓ The Basic Act on Education was revised in 2006 after 59 years.

- ✓ The basic plan for promoting education is formulated every five years.
- ✓ The digital textbooks become available due to institutional arrangements.

(Educational philosophy: balancing individually optimized and collaborative learning)

- ✓ In the 2020s, the educational philosophy related to the next Courses of Study emerged to balance individually optimized learning and collaborative learning.
- ✓ Around 2027, the next Courses of Study will be published, and changes in the subject "Informatics I" are expected to continue along with new educational philosophy.

As described above, the public and private sectors are collaborating to transform the subject "Informatics I" and are also working to shift to ICT-based education, which has been a challenge in Japan. In particular, Japan has established an environment in which students are gradually exposed to programming from elementary school and continue to learn in high school. In this process, while responding to the challenges of the time, institutional and budgetary measures were implemented, and steady progress was made in the development of ICT network environments, textbooks, teaching materials, and teacher training. Another characteristic of Japan is that a wide variety of textbooks has been published under the Courses of Study, which also respond to the diversity of learners.

This book publication focuses primarily on the transformation of the subject "Informatics I" in Japan. However, the European Commission has also conducted an international comparison of the implementation of "Informatics" education (European Education and Culture Executive Agency, 2022). There are also efforts to organize a common reference framework for the content of the subject "Informatics I" (Caspersen et al., 2022). Curriculum overload is not an issue unique to Japan, as the OECD released a report on the results of an international comparative study in 2020 (OECD, 2020). In these international discussions and efforts, Japan's experience in reforming "Informatics" can contribute in some areas. We hope that this book will contribute to international exchange.

In addition, although we did not discuss this in detail in this book, Japan has begun to implement next generation learning practices wherein students learn in fewer hours and in richer ways to cope with curriculum overload (Nasu, 2017, 2020, 2021a, 2021b, 2022). In addition, the revision of the next Courses of Study, which is expected to be in 2027, has been under discussion since around 2021, and its trends and discussions are also attracting attention (Watanabe, 2022). In addition, since this book has focused on "Informatics I," which is now a required course, it did not cover "Informatics II" which is also advanced and beneficial. In addition, the government is encouraging the establishment and expansion of "data science-" related departments in universities. These issues will be the subjects of future research and analysis.

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Appendix 1 Excerpts from the Courses of Study (Informatics I)

Section 10: Informatics

Subsection 1: Objective

Through learning activities in which students use scientific views and ideas about information to discover and solve problems by utilizing information technology, this Courses of Study aims to develop the following qualities and abilities to use information and information technology appropriately and effectively to discover and solve problems and to participate proactively in the information society:

(1) Deepen understanding and acquire skills in information and information technology and how to use them to discover and solve problems, as well as to deepen the understanding of the relationship between the information society and people
(2) Cultivate the ability to understand various phenomena as information and its connections, and to use information and information technology appropriately and effectively to discover and solve problems
(3) Cultivate an attitude of proactive participation in the information society as well as the appropriate use of information and information technology

Subsection 2: Subjects

No. 1. Information I

1 Objective

Through learning activities in which students use scientific views and ideas about information to discover and solve problems by utilizing information technology, this Courses of Study aims to develop the following qualities and abilities to use information and information technology appropriately and effectively to discover and solve problems and to participate proactively in the information society:

(1) Deepen understanding and acquire skills for effective communication and the use of computers and data, as well as to deepen the understanding of the relationship between the information society and people
(2) Cultivate the ability to understand various phenomena as information and its connections, and to use information and information technology appropriately and effectively to discover and solve problems.
(3) Cultivate an attitude of proactive participation in the information society as well as the appropriate use of information and information technology

2 Contents

[1] Problem solving in the information society
Focusing on methods of finding and solving problems using information and information technology, students are taught to acquire the following through activities to find and solve problems in the information society:

A. Acquire the following knowledge and skills
(a) Acquire methods to discover and solve problems by utilizing information and information technology, based on the characteristics of information and media
(b) Understand the laws and systems related to information, the importance of information security, individual responsibility in the information society, and information morality
(c) Understand the role and influence of information technology on people and society.

B. Acquire the following abilities of thinking, judgment, and expression
(a) Think about how to identify and solve problems using information and information technology appropriately and effectively according to the purpose and situation.
(b) Scientifically understand and consider the background of the significance of laws, regulations, systems, and manners related to information, the roles, and responsibilities of individuals in the information society, and information morality
(c) Consider the appropriate and effective use of information and information technology and the construction of a desirable information society

[2] Communication and information design
Thus, students can acquire the following through activities to convey information in an easy-to-understand manner to recipients according to their purposes and situations: focusing on media, means of communication, and information design.

A. Acquire the following knowledge and skills
(a) Understand the characteristics of media and communication through scientifically considering their transitions
(b) Understand the role of information design in people and society
(c) Understand the concepts and methods of information design for effective communication and acquire the skills to express them

B. Acquire the following thinking, judgment, and expressive skills
(a) Understand the relationship between media and the means of scientific communication and select them appropriately according to the purpose and situation
(b) Clarify the purpose of communication and consider appropriate and effective information design

(c) Express, evaluate, and improve based on the concept and method of information design for effective communication

[3] Computers and programming
Focusing on how information is processed by computers, students are taught to acquire the following through activities to discover and solve problems through programming and simulation:

A. Acquire the following knowledge and skills
(a) Understand the mechanisms and characteristics of computers and external devices and the limitations of the internal representation and computation of computer information
(b) Understand and acquire skills in expressing algorithms and methods for utilizing computers and information communication networks through programming
(c) Understand how to model events in society and nature, and how to evaluate and improve models through simulation

B. Acquire the following thinking, judgment, and expression skills
(a) Consider the relationship between the characteristics of information handled by computers and their capabilities
(b) Think of an algorithm according to the purpose and express it appropriately, utilize computers and information communication networks through programming, and evaluate and improve the process
(c) Model and simulate appropriately according to the purpose, and consider appropriate solutions to problems based on the results of the modeling and simulation

[4] Utilization of information and communication networks and data
Students are taught to acquire the following through activities to discover and solve problems by focusing on data distributed through information and telecommunications networks and utilizing the services provided by these networks and information systems.

A. Acquire the following knowledge and skills
(a) Understand the structure and components of information and telecommunications networks, the role of protocols, methods, and technologies to ensure information security
(b) Understand the methods of storing, managing, and providing data and the mechanisms and characteristics of information systems that provide services via information communication networks
(c) Understand and acquire the requisite skills to express and store data and understand the methods of collecting, organizing, and analyzing data

B. Acquire the following thinking, judgment, and expressive abilities
(a) Select the necessary components of the information communication network according to the purpose and situation, and consider how to ensure information security

(b) Think about the effective utilization of services provided by information systems
(c) Appropriate selection, implementation, evaluation, and improvement methods for collecting, organizing, analyzing, and expressing data and results

3 Handling of contents

(1) Regarding [1] through [4] of the contents, consideration should be given to the relationship with the study of information and information technology and the information society, the study of finding and solving problems, and the study of using data up to junior high school level.

(2) [1] of the content should be positioned as an introduction to this subject, and the relationship with [2] through [4] should be considered.

(3) For [2] A. (a), based on familiar and concrete examples of information design, the textbooks should include innovations that make ¥ operating computers and other devices easy, and those that make them accessible to all people regardless of age, disability, language, etc.

(4) As for A. (b) and B. (b) of [3], the structure of programs should be organized through the definition and use of functions, and the need for innovations to improve performance should also be mentioned. For A. (c) and B. (c), students should experience both cases of using a computer and not using a computer, and should also be exposed to the fact that differences in models can produce different results.

(5) For A. (b) and B. (b) of [4] of the contents, activities to design a small-scale network should be incorporated. (6) For (a) (b) and (b) (i), activities such as presenting and discussing the evaluation and improvement of their own information use should be included. A. (c) and B. (c) shall also include analysis methods according to the purpose, such as comparison, association, change, and classification.

*Japanese katakana notations have been converted to alphabetic characters as appropriate.

Appendix 2 An analysis of indexed terms of 12 textbooks of “Informatics I”

We aggregated the indexed terms in 12 textbooks of “Informatics I.” Some indexed terms mean the same, but are spelt differently (e.g., html and HTML, app and application). We counted those different spellings as different terms. The total indexed terms are 2,137. There are only 24 indexed terms which appear in all 12 textbooks. This means that each textbook has strong areas. This project member will work on further analysis of those indexed terms.

Table Appendix - 1 Total words indexed: 2,137

Textbook No.	Number of indexed terms
701	304
702	578
703	673
704	693
705	662
706	365
707	186
708	385
709	429
710	454
711	300
713	492

Table Appendix - 2 Number of textbooks and commonly indexed terms

Number of textbooks	Indexed words contained
12	24
11	29
10	30
9	30
8	34
7	31
6	61
5	87
4	116

3	181
2	533
1	981

Appendix 3: Prototype test of the Common Test subject “Informatics I”

A tentative translation of the prototype questions for the Common Test subject "Information I" is included on the following pages. The Japanese version can be accessed at the following URL https://www.dnc.ac.jp/kyotsu/shiken_jouhou/r7/r7_kentoujoukyou/r7mondai.html.

○How to answer

1: Mark your answer in the answer box corresponding to the question number on the answer sheet.

If you answer ③ to the question indicated ア in **Question 2**, **mark** ③ in the **answer column** of "**ア**" of Question 2 as shown in the following example.

Example 1:

2	Answer Column
	0 1 2 3 4 5 6 7 8 9 ・・・・
ア	⓪ ① ② ● ④ ⑤ ⑥ ⑦ ⑧ ⑨ ・・・・

2: If you are asked to enter a number (0-9) or a letter (a-d) in such イウ in the sentence of the question, answer the question in the designated column on the answer sheet in the following way.

Example 2: If you want to answer "38" in イウ,

イ	⓪ ① ② ● ④ ⑤ ⑥ ⑦ ⑧ ⑨ ・・・・
ウ	⓪ ① ② ③ ④ ⑤ ⑥ ⑦ ● ⑨ ・・・・

When ア, イウ, etc. appear more than once in the same question statement, as principle, they should be written in small letters such as ア, イウ, etc. in the same question statement from the second time onwards.

The 2025 Common University Entrance Exam

Prototype Questions of "Information I"

○Exam time: 60 minutes

○Scope of exam: "Information I"

○Purpose and points to be noted

This prototype questions have been prepared and published in order to share a concrete image of "Information I," which will be newly set as a subject for the 2025 Common University Entrance Exam.

Although these exam questions have been created by experts, the process of creating and inspecting them was not the same as that used for the National Center Tests for University Admissions and Common University Entrance Exam in the past.

The content for the 2025 Common University Entrance Exam will continue to be reviewed based on the preparation of this prototype questions.

*Please refer to the "Overview of Prototype Questions of 'Information'" for an explanation of this prototype questions.

Information I

(all questions must be answered)

Question 1 Answer the following questions (Q1-4) (allocation of marks: 20 pts).

Q 1 : Answer the following questions (a and b) regarding the use of Internet-based services.

a: Select the most appropriate two answers from the following choices from ⓪ to ⑤ as cautions and judgments when using SNS, e-mails, and websites. However, the order of the answers does not matter.

ア ・ イ

⓪ You must reply to a message as soon as possible at any time when you receive the one.

① Even when communicating via SNS or email with someone you trust, you should be aware of the possibility that someone with malicious intent could be impersonating your trusted person.

② If you post anonymously on a web page, you will not be identified.

③ In a private group on an SNS, there is no problem to post personal information, no matter what type of the group it is.

④ Posting images of well-known cartoon characters on SNS profiles without permission constitutes copyright infringement.

⑤ Since celebrities are known to many people, posting pictures of celebrities on an SNS does not violate the rights of portrait.

b: Select the most appropriate answer from the following choices from ⓪ to ③ as a method to verify the credibility of information on the Internet.

ウ

⓪ Judge information by whether or not the website appears high on the search engine results.

① Judge the answers on the Q&A website by whether they are chosen as the best answers that are supported by many people.

② Judge information posted on an SNS by the number of shares and "likes."

③ Make a judgment after checking, comparing, and verifying not only the specific website but also books, multiple websites, etc.

Q2: Select the most appropriate answer from the following group of answers for each of the blanks エ・オ in the following passage.

In data communication, one of the methods to check for errors in received data is parity check. In this method, parity bits are added to the data to detect errors in the data. In this case, the number of 1s in the transmitted data is counted, and if the number of 1s is even, parity bit 0 is added to the transmitted data, and if the number of 1s is odd, parity bit 1 is added to the transmitted data for data communication. For example, as shown in Figure 1, when the transmission data is “01000110,” the parity bit is 1, so the sender adds the parity bit and transmits the data “010001101.”

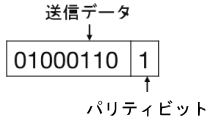


Figure 1: Transmitted data ”01000110” and the parity bi

The receiver can judge whether an error occurred during data communication depending on whether the number of 1's in the data is even or odd. Based on this idea, エ .

For example, the data in binary 8-bit representation of "7A" in hexadecimal with the addition of parity bits as in Figure 1 is オ .

Answer group of エ

⓪ if there is an error in the parity bit, it is not possible to determine whether the data is erroneous or not

① you can determine if one bit is faulty, including the parity bit, but you don't know which bit is faulty

② you can determine if a single bit is faulty, including parity bit, and you know which bit is faulty as well

③ you can determine if two bits, including the parity bit, are faulty, but you don't know which bit is faulty

④ you can determine if two bits are faulty, including the parity bit, and you know which bit is faulty

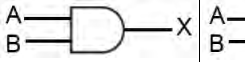
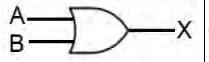
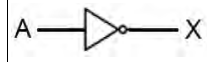
Answer group of オ

⓪ 011110100	① 011110101	② 011110110
③ 011110111	④ 101001110	⑤ 101001111

Q3: Read the following passage and choose the most appropriate answer from the following group of answers to fill in the blanks from カ to ク .

The three basic logic circuits are the AND circuit, the OR circuit, and the NOT circuit. Their symbols and truth table are shown in Table 1 below. A truth table shows the relationship between inputs and outputs.

Table 1 Symbols and truth table

Circuit	AND circuit	OR circuit	NOT circuit
Symbol			
Truth table	入力 A B / 出力 X 0 0 / 0 0 1 / 0 1 0 / 0 1 1 / 1	入力 A B / 出力 X 0 0 / 0 0 1 / 1 1 0 / 1 1 1 / 1	入力 A / 出力 X 0 / 1 1 / 0

(1) An airplane owned by Airline S has two toilets (A and B) in the rear of the aircraft. When both toilets A and B are in use at the same time, a light on the panel in front of the passenger's seat turns on to inform the passengers that the toilets are occupied. Input A is set to 1 when toilet A is in use and 0 when it is unoccupied, and the same is true for toilet B. Output X is set to 1 when the lamp is on, and 0 when it is not. The logic circuit to realize this is shown in Figure 2.

Figure 2 Logic circuit of (1)

(2) The airline S decides to purchase a new passenger plane. In this airliner, the number of toilets is increased to three (A, B, and C), and a light is turned on to notify of the congestion when any two or more of the three toilets are in use. The inputs and outputs are the same as in (1). The truth table in this case is キ , and the logic circuit that realizes this is shown in Figure 3.

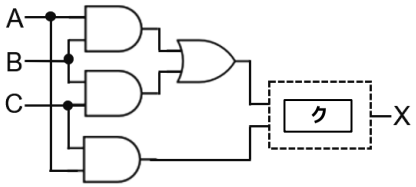
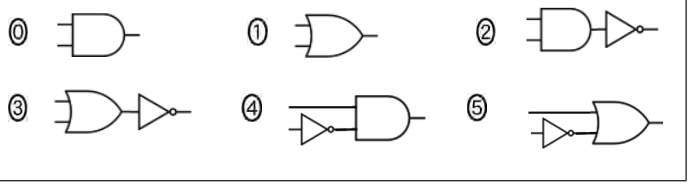


Figure 3 Logic circuit of (2)

Answer group of カ and ク



Answer group of キ

⓪

入力			出力
A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	1

①

入力			出力
A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	0
1	1	1	1

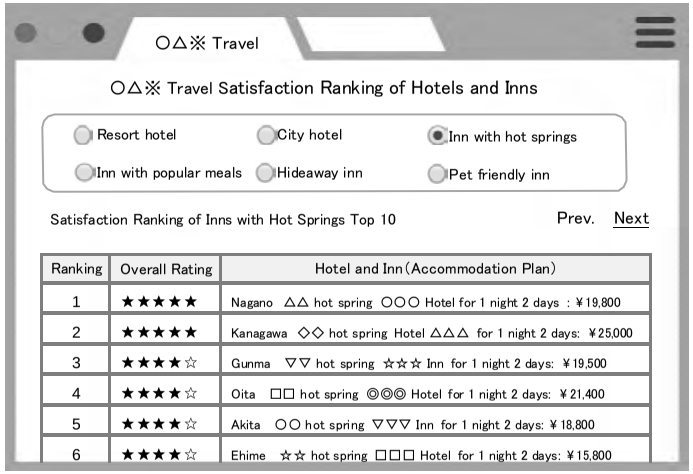
②

入力			出力
A	B	C	X
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

③

入力			出力
A	B	C	X
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	1
1	0	1	1
1	1	0	1
1	1	1	1

Figure 4
Railroad route map



Ranking	Overall Rating	Hotel and Inn (Accommodation Plan)
1	★★★★★	Nagano △△ hot spring ○○○ Hotel for 1 night 2 days : ￥19,800
2	★★★★★	Kanagawa ◇◇ hot spring Hotel △△△ for 1 night 2 days: ￥25,000
3	★★★★☆	Gunma ▽▽ hot spring ☆☆☆ Inn for 1 night 2 days: ￥19,500
4	★★★★☆	Oita □□ hot spring ◎◎◎ Hotel for 1 night 2 days: ￥21,400
5	★★★★☆	Akita ○○ hot spring ▽▽▽ Inn for 1 night 2 days: ￥18,800
6	★★★★☆	Ehime ☆☆ hot spring □□□ Hotel for 1 night 2 days: ￥15,800

Figure 5 Satisfaction ranking of inns with hot springs

Q4: Read the following passage and choose the most appropriate answer from the following group of answers to fill in the blanks from ケ to サ . The order of the answers in the blanks コ and サ does not matter.

Richard S Wurman of the United States has proposed the “five ultimate hat racks" as a method for organizing and expressing information. According to this principle, although information is infinite, it can be organized and categorized according to the following five criteria.

・Place: Based on physical location (e.g. population of a prefecture and university campus map)
・Alphabet: Based on linguistic order (Japanese syllabary in Japanese)(e.g. dictionary and phone book)
・Time: Based on before/after time relationship (e.g. historical chronology and schedule)
・Category: Based on areas distinguished by differences in things (e.g. biological classification, library bookshelf)
・Hierarchy (sequential quantity): Based on quantitative changes such as large and small, high and low, etc. (e.g. To-Do list sorted by priority and file size)

According to the criteria, the "railroad route map" in Figure 4 is organized based on ケ , and the "satisfaction ranking of inns with hot springs" provided on the website of a certain travel agency in Figure 5 is considered to be organized and categorized based on コ and サ .

Answer group from ケ to サ

⓪ place　① alphabet　② time
③ category　④ hierarchy (sequential quantity)

Question 2 Answer the following questions (A and B) (allocation of marks: 30 pts).

A : Read the following conversation between Taro and his teacher and answer the questions (Q1-4).

Taro: Two-dimensional codes are used in many places and are very useful.

Teacher: There are many different types of two-dimensional codes, but the ones we see every day were invented by Japanese companies.

Taro: That is an amazing invention. Since they are a company invention, did they patent it?

Teacher: Of course. [ア] They have become widely used.

Figure 1 Example of 2D code

Taro: How much information can it contain?

Teacher: It depends on the size, but the size of Figure 1 can hold 187 characters for numbers, 78 characters for lowercase alphabets, and 48 characters for symbols and kanji. What are the shape characteristics of a two-dimensional code?

Taro: It consists of small black and white squares, with slightly bigger double squares in each of the three corners.

Teacher: The small black and white squares are called cells and are coded as 1 and 0. The two-dimensional code shown in Figure 1 consists of 33 x 33 cells, but the number of cells changes according to the type of character, number of characters, etc., and the size of the two-dimensional code changes accordingly. A The double slightly bigger squares in the three corners are position detection marks that tell the reader that this 2D code is there.

Taro: This 2D code can be read correctly even if it is partially hidden.

Teacher : B It is an error correction function. It can be used for product management in factories, etc. Even if a part of the code cannot be read due to dirt, damage, etc., it can be restored. There are four levels of restoration depending on the percentage of unreadable area.

Taro: It's an amazing technology.

Teacher: Yes, it is. You can create your own 2D codes, so why don't you have a try?

Q1: Select the most appropriate statement that fits the blank [ア] from the following⓪-③.

⓪ Then, since the value of the two-dimensional code has been increased by increasing the royalty fee
① However, since the patent right was subsequently abandoned so that anyone can obtain the patent
② Then, because they tightened the control by enforcing the patent right
③ But because they said that they would not exercise their right even if they owned the patent

Q2: The marks in the underlined part A can be recognized as a 2D code mark when the ratio of black-white-black-white-black is 1:1:3:1:1, no matter

Q3: Taro was taught by his teacher about a Web application like the one shown in Figure 4 that can create 2D codes. This 2D code image creation tool can create an image of a 2D code by specifying the character string, size of the cell, level of error correction (restoration capability), and image file format for a 2D code.

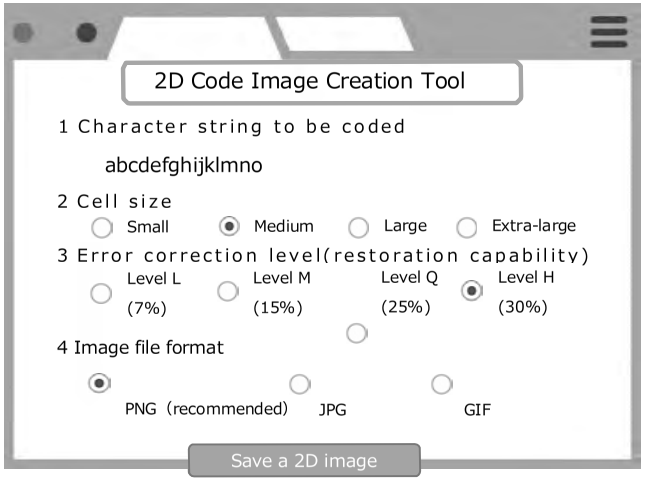


Figure 4 Screen of a 2D code image creation tool

Taro interested in the underlined part B decided to use this creation tool to investigate how the length of the character string and the level of error correction for a 2D code affect the number of vertical and horizontal cells. For that purpose, he has created a 2D code by changing the number of characters in a character string consisting of lower-case letters (a-z), and the results are as shown in Table 1. In the table, n x n represents the number of vertical and horizontal cells, respectively.

In this tool, the number of vertical and horizontal cells is automatically adjusted to the optimum number. The higher the restoration capability value (%), the higher the error correction capability. For example, a restoration capability of 30% means that data can be restored even if a maximum of 30% of the area of the 2D code cannot be read.

at which angle it is read, for example, from (a) to (c), as shown in Figure 2. The same could be considered true for a circular mark as shown in Figure 3, but a square one is more convenient. Select the most appropriate reason for this from the following - . イ

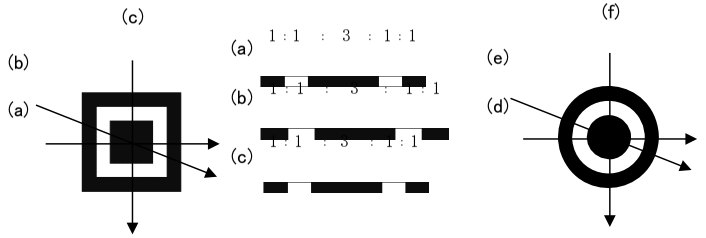


Figure 2 Position detection marks and their black and white ratio

Figure 3 Circular marks

⓪ In a circular shape, the ratio of black and white may differ depending on the angles from (d) to (f), which may result in incorrect readings.
① If it is circular, it has no top, bottom, left, and right, so the orientation of the 2D code is not clear.
② Depending on the resolution of the printer or display, it is more difficult to make a small circular mark that can be read correctly compared to a square one.
③ This is because a circular shape cannot be read correctly if the mark is obliquely tilted, as it cannot be recognized.

Table 1 2D codes created by changing the number of characters in a character string consisting only of lower-case alphabetic characters and the restoration capability.

	15characters	20characters	30characters	40characters
Restoration capability 7%	 21×21	 25×25	 25×25	 29×29
	 29×29	 29×29	 33×33	 37×37

Select two appropriate statements from the following⓪-⑤ based on the results of Table 1. The order of the answers does not matter. ウ ・ エ

⓪ With the same restoration capability, the number of cells increases in proportion to the number of characters, and with the same cell size, the 2D code also becomes larger.

① For each restoration capability, the number of vertical and horizontal cells is determined within a certain range of the number of characters, and the number of vertical and horizontal cells increases step by step as the number of characters increases.

② There is no relationship between the number of characters and the number of cells.

③ A 2D code created with a certain character string with a restoration capability of 30% has about four times as many cells as a 2D code created with the same character string with a restoration capability of 7%.

④ More information is needed to achieve a restoration capability of 30% compared to a restoration capability of 7%.

⑤ For the same number of characters, the number of cells remains the same even if the restoration capability is changed.

Answer group from [オ] to [ク]

⓪ 33×33

① 49×49

② 25×25

③ 37×37

Q4: Next, Taro tried using the web application shown in Figure 4 to create 2D codes for the three character strings from I to III shown in Table 2. He created 2D codes with both 7% and 30% restoration capabilities, and changed the cell sizes in various ways, resulting in the 2D codes shown in Table 3. As a result, the number of cells in the 2D codes created for each of the 7% and 30% restoration capacities were different for character strings from I to III. Since the character strings from I to III include alphabetic characters, symbols, and Chinese characters, it was found that the number of characters in the character strings consisting only of lower-case alphabetic characters shown in Table 1 and the number of vertical and horizontal cells were not necessarily related to each other. Select one appropriate 2D code from the group of the answers below for each of the blanks from [オ] to [ク] in Table 3.

Table 2 Character strings used for the 2D codes

Ⅰ	https://www.example.ne.jp/
Ⅱ	ＤＮＣ高等学校 https://www.example.ne.jp/
Ⅲ	ＤＮＣ高等学校 東京都目黒区駒場*-**-** https://www.example.ne.jp/

Table 3 2D codes created from the character strings from Ⅰ to Ⅲ

2D code of Ⅰ Restoration capability of 7% [オ]	2D code of Ⅱ Restoration capability of 7% 29×29	2D code of Ⅲ Restoration capability of 7% [カ]
2D code of Ⅰ Restoration capability of 30% 33×33	2D code of Ⅱ Restoration capability of 30% [キ]	2D code of Ⅲ Restoration capability of 30% [ク]

B: Read the following passage and answer the questions (Q1-3).

M-san's class decided to sell crepes for two days during a school festival. On the first day, customers often had to wait because they were not accustomed to serving the food. Therefore, at the end of the first day, they decided to simulate how the waiting situation would change if the cooking procedures were changed. At this shop, it is assumed that only one customer can be served at a time and that a customer can only order one crepe at a time. Also, it is assumed that a customer is asked for his/her order after the previous customer has been given his/her food.

Q1: Mark a number for each of the following blanks from ケ to シ in the following sentences and table.

First, M-san analyzed the records for Day 1 and found that it took approximately 4 minutes to serve each customer from the time of order to the time of delivery of the goods. Next, since the class recorder had recorded the customer arrival times for the first day, they examined the arrival intervals for the first 50 customers and found the number of people shown in Table 1. The relative frequencies were determined from these numbers of people, and the cumulative relative frequencies were considered as probabilities. Since the arrival intervals were compiled based on a certain range, they considered each range using a class value.

Table 1 Arrival intervals and number of customers

Arrival intervals (sec.)	# of customers	Class value	Relative frequency	Cumulative relative frequency
0-30	6	0 min.	0.12	0.12
30-90	7	1 min.	0.14	0.26
90-150	8	2 min.	0.16	0.42
150-210	11	3 min.	0.22	0.64
210-270	9	4 min.	0.18	0.82
270-330	4	5 min.	0.08	0.90
330-390	2	6 min.	0.04	0.94
390-450	0	7 min.	0.00	0.94
450-510	1	8 min.	0.02	0.96
510-570	2	9 min.	0.04	1.00
570 or longer	0	-	-	-

Then, using a random number (a uniform random number with the same probability of occurrence of a number between 0 and 1) generated by a spreadsheet software, the arrival intervals of the first 10 persons were derived based on Table 1. Table 2 shows the results. The arrival intervals here are based on the class values in Table 1. The first person is assumed to have an arrival interval of 0 minute.

Table 2 Arrival intervals derived from random numbers

	Generated random numbers	Arrival intervals
1st	–	0 min.
2nd	0.31	2 min.
3rd	0.66	4 min.
4th	0.41	2 min.
5th	0.11	0 min.
6th	0.63	3 min.
7th	0.43	3 min.
8th	0.28	2 min.
9th	0.55	3 min.
10th	0.95	ケ min.

In order to get an idea of the waiting status of the 10 customers from the results of Table 2, they decided to represent them as shown in Figure 1 below (Figure 1 is filled in up to the sixth customer). The waiting time is defined as the time from the beginning of waiting in line until the end when the person in front of the waiting person finishes his/her serving time, excluding the number of waiting customers who are being served. In this case, the highest number of people waiting in line was コ (this is called the maximum number of people waiting). and the longest waiting time among the customers was サシ minutes.

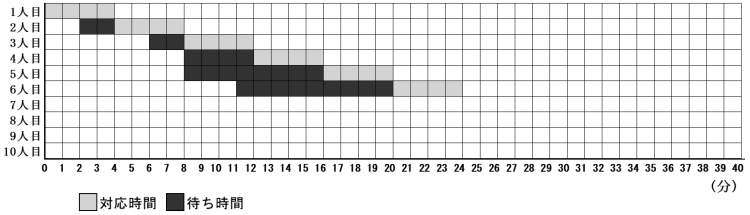


Figure 1 Simulation results (in preparation)

Q2: Since the results in Figure 1 was based on the case of 10 customers, M-san wanted to know what the waiting situation would be like if more customers arrived. Therefore, M-san conducted 100 simulations with 10, 20, 30, and 40 customers, respectively. Figure 2 below shows the frequency of the maximum number of customers waiting in each of the 100 simulations.

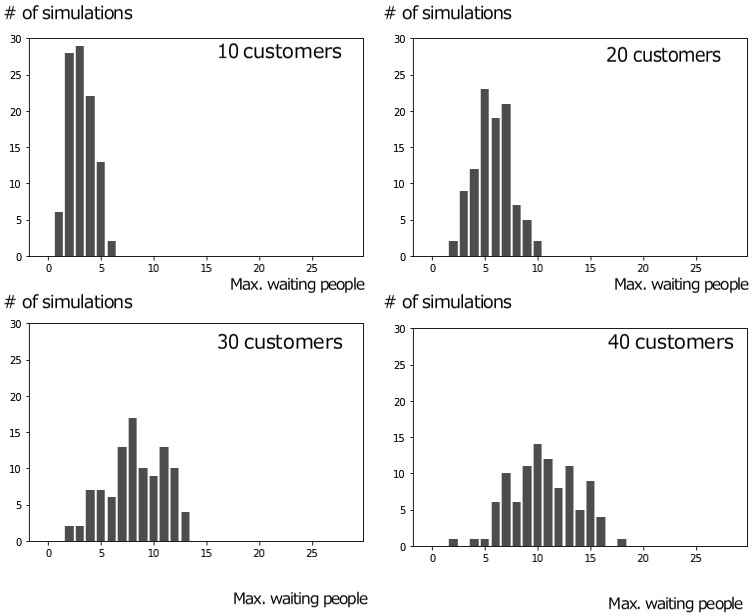


Figure 2 Simulation results

For this example, select one of the following ⓪ - ③ that cannot be read from the simulation results. [ス]

⓪ The larger the number of customers, the larger the maximum waiting people tend to be.

① The distribution of the maximum number of waiting customers is less than half of the total number of customers visiting the shop.

② It is more frequent for the maximum number of waiting people to be around 1/4 of the total number of customers.

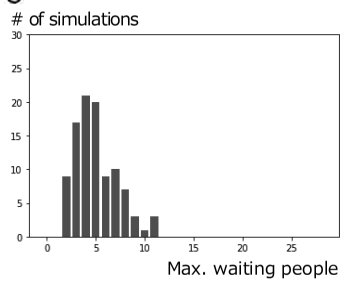
③ Higher the number of customers, the greater the dispersion of the maximum number of people waiting.

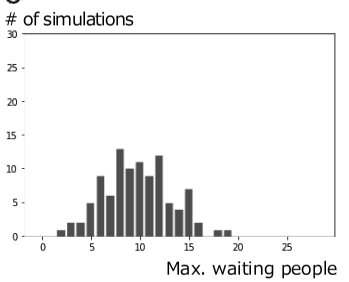
Question 3 Answer the following questions (Q1-3) (allocation of marks: 25 pts).

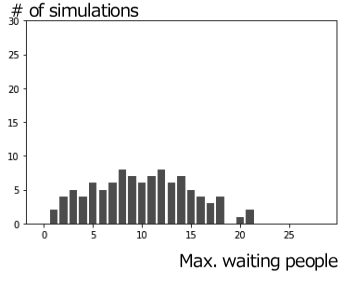
Q1: Read the following conversation between a student (S) and teacher (T) and mark the appropriate number for the blank [ア]. Also, select the most appropriate answer for each of the blanks from [イ] to [エ] from the following answer group. The order of the answers in the blanks [ウ] and [エ] does not matter.

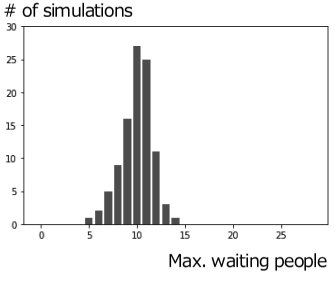
S : The other day, I saw a customer pay 510 yen for a 460 yen item and receive 50 yen in change, and I wanted to make a program to calculate such a "good way to pay" using the programming we studied in class.
T: That's good. But first we need to define what is a "good way to pay."
S: I guess it is usually a way to pay to reduce the number of coins you carry.
T : Yes, that's right. But how about we consider a payment method that minimizes the sum of the number of coins the customer pays and the number of coins the customer receives in change? Let us assume that both the customer and the store have a sufficient number of coins. To simplify the calculation, let us also assume that the price is less than 100 yen, and that the customer uses only 1-yen, 5-yen, 10-yen, 50-yen, and 100-yen coins, and no 500-yen coin. For example, if you pay 46 yen, how many coins will you pay?
S : To pay 46 yen, the minimum number of coins to pay is six: four 10-yen coins, one 5-yen coin, and one 1-yen coin.
T : That's right. On the other hand, if we pay 51 yen and receive 5 yen in change to pay 46 yen, we will exchange 2 coins for payment and 1 coin for change, resulting in a total of 3 coins exchanged. In this way, the total number of coins exchanged is minimized.
S : This is a good way to pay.
T : Yes, that's right. In this way, let us consider the calculation of the "minimum number of coins to be exchanged", in other words, the minimum number of coins exchanged between the customer and the store.
S : But, I wonder how to figure this out.
T : Let us consider how to program and use the following function, which can find the minimum number of coins required to pay in exact change.

Q3: The number of customers on the morning of the first day was 39, and according to the record, there were 10 people waiting in the longest line, so M-san thought that the result of "40 customers" in Figure 2 roughly reproduced the situation on the morning of the first day. Therefore, they tried to see how the result of "40 customers" in Figure 2 would change if the time required to serve one customer could be reduced from 4 minutes to 3 minutes by changing the cooking procedure, using the same random number sequence. Select the most appropriate graph from the following ⓪ - ③ that shows the result. [セ]

⓪


①


②


③


【Explanation and Example of the Function】

Number of coins (amount (of money)): The "amount" is given as an argument to the function, and its return value is the smallest number of coins among the combinations of coins that pay in exact change.
Example: Since the smallest number of coins for 8 yen is the combination of "one 5-yen coin and three 1-yen coins," the value of the **number of coins** (for 8) is 4.

T: This is a function that calculates, for example, the **number of coins** (46) = [ア]. Let us consider the calculation of the minimum number of coins exchanged using this function. For example, if a customer pays 51 yen and receives 5 yen in change for 46 yen, how can this function be used to calculate the total number of coins exchanged between the customer and the store?

S: We can calculate it by [イ].

T: In general, for a commodity price of x yen, the change of y yen is changed to 0, 1, 2, and so on, and the total number of coins required in each case is calculated using the following formula,

Number of coins ([ウ]) + **Number of coins** ([エ]),

to obtain the smallest number of coins exchanged.

S: I see. So, how far should I check the change of y?

T: This is an interesting mathematical puzzle. Let's think about the details next time. In this case, since the product costs less than 100 yen, it should be enough for y to be checked up to 99.

Answer group of [イ]

⓪ **# of coins** (51) + **#of coins** (5)
① **# of coins** (46) + **#of coins** (5)
② **# of coins** (51) - **#of coins** (5)
③ **# of coins** (46) - **#of coins** (5)

Answer group of [ウ] and [エ]

⓪ x
① y
② $x + y$
③ $x - y$

Q2: Select the most appropriate answer from the following group of answers for each of the blanks from [オ] to [コ] in the following passages.

S: First, I would like to create a program for the function "**number of coins** (amount)," which calculates the minimum number of coins that will pay in exact change. But, I would like to have some more hints.

T: I suggest that you calculate the number of coins and the remaining amount of money to be paid by first using the coins with the highest value in relation to the amount of money. To calculate how many coins with a certain value can be used for a given amount of money and how much money is left, you can use the operations, "÷" for the integer quotient and "%" for the remainder. For example, you can use [オ] to find out how many 10-yen coins can be used for 46 yen, and [カ] to find out how much remains.

S: I see! I think I can do the rest by myself.

After getting the hint from a conversation with the teacher (T), S-san designed a program that calculates the smallest number of coins that will pay in exact change for the target amount (less than 100 yen) given in the variable, **`kingaku`**, (Figure 1). Here, as an example, the target amount is set to 46 yen.

The coins are set in the array, **`Kouka`**, in ascending order of value. The additional character of the array is assumed to start from **`0`**. The value of **`Kouka[0]`** is **`1`** because the lowest coin is a 1-yen coin.

In accordance with the hint given by the teacher (T), an iteration statement like lines **`(4)-(6)`** is used with the policy of calculating the number of coins starting with coins of the highest value. In this iteration, a variable, **`maisu`**, calculates the total number of coins to be paid, and a variable, **`nokori`**, calculates the remaining amount of money to be paid.

After running the program, [ア] is displayed, which indicates that the calculation was performed correctly. Then, various examples were tested, and it was confirmed that all calculations were done correctly.

```
(1) Kouka = [1,5,10,50,100]
(2) kingaku = 46
(3) maisu = 0, nokori = kingaku
(4) Repeat i by [キ]:

(5)   maisu = [ク] + [ケ]
(6)   nokori = [コ]
(7) Display(maisu)
```

Figure 1 Program calculating the smallest number of coins that pay in exact change for a targeted amount

Answer group of [オ] and [カ]

⓪ 46 ÷ 10 + 1　　① 46 % 10 − 1
② 46 ÷ 10　　③ 46 % 10

Answer group of [キ]

⓪ Reducing by **1** from **5** to **1**　　① Reducing by **1** from **4** to **0**
② Increasing by **1** from **0** to **4**　　③ Increasing by **1** from **1** to **5**

Answer group of [ク]

⓪ **1**　　① **maisu**　　② **i**　　③ **nokori**

Answer group of [ケ] and [コ]

⓪
② **nokori ÷ Kouka[i]**
maisu ÷ Kouka[i]

①
③ **nokori % Kouka[i]**
maisu % Kouka[i]

Q3: With reference to the following sentences, select the most appropriate answer from the following group of answers for each of the blanks from [サ] to [タ] in the program shown in Figure 2. However, the order of the answers for the blanks of [ス] and [セ] does not matter.

T :It looks like you have created a program (Figure 1). Using it, you can perform the function, "**number of coins** (amount of money)." If you set the value of the amount given as the argument of the function to the variable, **kingaku**, in the program (Fig. 1) and set the value of the variable, **maisu**, to the return value of the function instead of line (7), you will have a program for the function, "**number of coins** (amount of money)." Now, let's create a program that uses the function to calculate the minimum number of coins exchanged. Again, let us assume that the item costs less than 100 yen.

【Explanation of the Function】(as stated before)

Number of coins (amount (of money)): The "amount" is given as an argument to the function, and its return value is the smallest number of coins among the combinations of coins that pay in exact change.

S-san created the program as shown in Figure 2. The program prepares a variable, **tsuri**, representing change for the price of the commodity given to the variable, **kakaku**, checks the number of coins exchanged for all reasonable values of **tsuri**, and finds the minimum value. As an example, the price of the product is set at 46 yen.

In this program, following the advice of the teacher (T), the numbers of coins to be exchanged for every change up to 99 yen, including the case of no change, are calculated, and the minimum value is considered as the minimum number of coins exchanged.

To calculate the minimum value, each time a new minimum number of coins requires less than the previous minimum number of coins, the variable, **min_maisu**, is updated. The initial value of **min_maisu** is 100, which is sufficiently large, because the number of coins used for a product of 100 yen or less does not exceed 100 coins.

Answer group of サ , ソ , and タ

⓪ maisu ① min_maisu ② shiharai ③ tsuri

Answer group of シ

⓪ 0 ① 1 ② 99 ③ 100

Answer group of ス and セ

⓪ ① ②
③ # of coins (shiharai) ④ # of coins (kakaku) ⑤ # of coins (tsuri)
shiharai kakaku tsuri


```
(1) kakaku = 46
(2) min_maisu = 100
(3) Repeat サ by increasing from シ up to 99 by 1:
(4)     shiharai = kakaku + tsuri
(5)     maisu = ス + セ
(6)     If ソ < min_maisu :
(7)         タ = ソ
(8) Display (min_maisu)
```

Figure 2 Program to obtain the minimum number of coins exchanged

When this program was run, 3 was displayed, showing that the calculation was correct, since the minimum number of coins exchanged when paying 46 yen is three: one 50-yen coin and one 1-yen coin for the payment, and one 5-yen coin for the change. In the same way, when they tried running the program with various values of **kakaku**, they were able to confirm that all calculations were correct.

(Source: Created based on "Survey on Time Use and Leisure Activities in 2016" by Statistics Bureau of MIC)

Question 4 Read the following passages and answer the following questions (Q1-5) (allocation of marks: 25 pts).

Table 1 below shows the average times (minutes) spent in each activity on weekdays by prefecture for young people aged 15 to 19, based on a national statistical survey on the actual status of time spent in daily life, The average times are divided into groups based on the amount of time spent using smartphones and PCs. Table 1-A shows those who spend less than one hour a day using smartphones and PCs, and Table 1-B shows those who spend three to six hours a day using smartphones and PCs.

Table 1-A: The average times by prefecture for those who use smartphones, PCs, etc. for less than one hour in their daily activities

Prefecture	Sleeping (min.)	Personal affairs (min.)	Eating (min.)	Commut-ing (min.)	Studying (min.)	Hobbies (min.)
Hokkaido	439	74	79	60	465	8
Aomori	411	74	73	98	480	13
Ibaraki	407	61	80	79	552	11
Tochigi	433	76	113	50	445	57

Table 1-A: The average times by prefecture for those who use smartphones, PCs, etc. for three to six hours in their daily activities

Prefecture	Sleeping (min.)	Personal affairs (min.)	Eating (min.)	Commut-ing (min.)	Studying (min.)	Hobbies (min.)
Hokkaido	436	74	88	63	411	64
Aomori	461	57	83	55	269	44
Ibaraki	443	80	81	82	423	63
Tochigi	386	120	79	77	504	33

Hanako and her peers set Table 1-A as the group with short time spent on smartphones and PCs, and Table 1-B as the group with long time spent on smartphones and PCs. Based on these data, they decided to analyze the relationship between the time spent on smartphones and PCs and time spent on daily activities.

However, if there is a missing value in even one of the data items in Tables 1-A and 1-B, the data set excluding the prefecture with the missing value is considered as the entire data. In the following, the range of data includes outliers.

Q1: Hanako and her peers came up with the following hypotheses based on these data. Select one of the following hypotheses from ⓪ to ③ that **cannot be analyzed** from the data in Table 1-A and Table 1-B alone.

ア

⓪ The group of young people who spend more time on smartphones, computers, etc. may tend to spend less time eating than the group who spend less time on smartphones and computers.

① Focusing on the group of young people who use smartphones and PCs for longer periods of time, there may be a tendency for them to use smartphones and PCs longer at night than in the morning.

② Focusing on the group of young people who spend more time using smartphones, computers, etc., those prefectures where students spend more time on schoolwork may tend to spend less time on hobbies and leisure activities.

③ There may be no relationship between the time spent on smartphones, computers, etc. and the length of time spent commuting to and from school among young people.

Q2: From the data in Tables 1-A and 1-B, Hanako and her peers focused on sleeping and studying times, and summarized them in the boxplots in Figures 1 and 2 (outliers are marked with ○), respectively. Select the most appropriate one that can be read from the following from ⓪ to ③.

イ

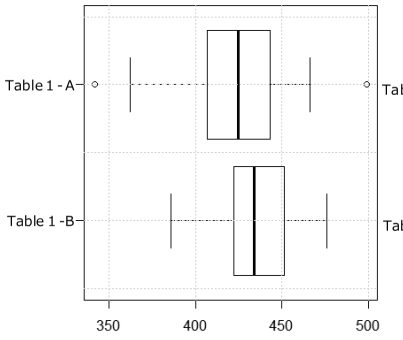


Figure 1 Distribution of sleeping time

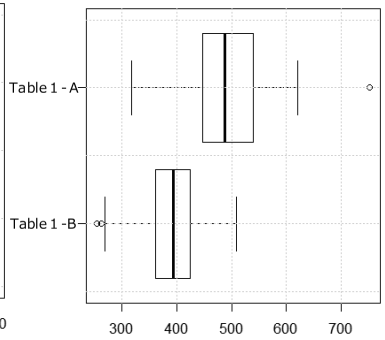


Figure 2 Distribution of studying time

⓪ When looking at the number of prefectures where sleeping time is 420 minutes or more, Table 1-A shows more such prefectures than Table 1-B.

① More than half of the prefectures in Table 1-A have more than 550 minutes of studying time while none of the prefectures in Table 1-B have more than 550 minutes of studying time.

② In Table 1-B, more than 75% of the prefectures have less than 450 minutes of studying time, and in Table 1-A, less than 50% of the prefectures have less than 450 minutes of studying time.

③ When comparing the sleeping time and studying time by prefecture, the absolute difference in medians between Tables 1-A and 1-B is larger in the sleeping time.

Q3: Hanako and her peers decided to find out whether differences in the length of time spent on smartphones, computers, etc. had a greater effect on sleeping time or studying time. For this purpose, they considered the difference between the values in Table 1-A minus the values in Table 1-B for both sleeping time and studying times in each prefecture, and the results are shown in the boxplot in Figure 3 below (outliers are marked with○). Which of the following statements about Figure 3 is correct from A to E? Select the most appropriate combination from the following ⓪ to ⑤. ウ

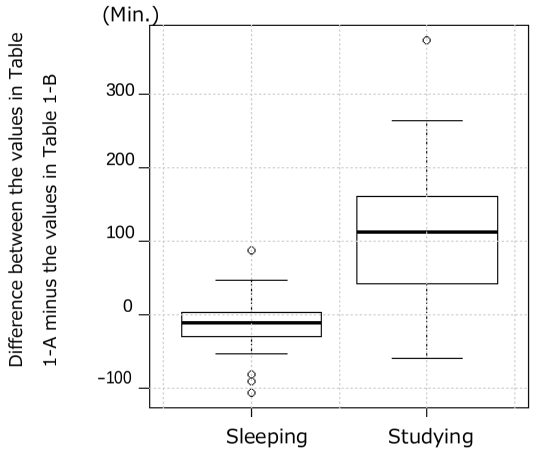


Figure 3 Difference in time of daily activities

(Rough Paper)

Information I exam questions continue on the next page.

Q4: Hanako and her peers decided to examine the relationship between sleeping time and studying time for Table 1-A. Figure 4 below shows a scatter diagram of sleeping time and studying time for Table 1-A. The two overlapping points that cannot be distinguished are indicated by □.

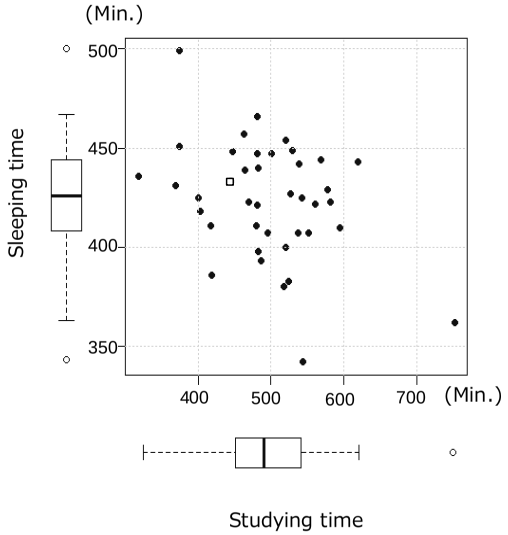


Figure 4 Scatter diagram of studying and sleeping times in Table 1-A

A For young people in the prefectures with a positive difference in studying time, the group with shorter time spent on smartphones, PCs, etc. tended to spend more time on their studies.

B For young people in the prefectures with a positive difference in sleeping time, the group with shorter time spent on smartphones, PCs, etc. tended to sleep shorter.

C The difference in time spent on daily activities due to time spent on smartphones, computers, and etc. is more evident in studying time than sleeping time.

D The difference in time spent on daily activities due to time spent on smartphones, computers, and etc. is more evident in sleeping time than studying time.

E The difference in time spent on daily activities due to time spent on smartphones, computers, and etc. is shown equally in both studying and sleeping times.

⓪ A and C　① A and D　② A and E
③ B and C　④ B and D　⑤ B and E

Q5: Read the following passages and mark the appropriate number in the blank オ. Select the number that best fits in the blank カ from ⓪ to ③ in Figure 6. Select the most appropriate answer for the blank キ from the following group of answers.

Hanako and her peers obtained a regression line explaining the sleeping time by the studying time for each prefecture, and added it to the scatter diagram in Figure 4 (Figure 5). They found that many prefectures were far from the regression line, so they decided to examine how far their prefecture, P, was out of the line by considering the difference (residual error) between the actual sleeping time and the sleeping time estimated from the regression line. For this purpose, to make it easier to compare the residual error, they created a graph (Figure 6) with the sleeping time (estimated value) estimated from the studying time based on the regression line on the horizontal axis and the value (converted value) obtained by converting the residual error to the mean value of 0 and the standard deviation of 1 on the vertical axis. For reference, the location of prefecture Q is shown in each figure. The points indicated by □ in Figure 5 are circled in black for the convenience of the question.

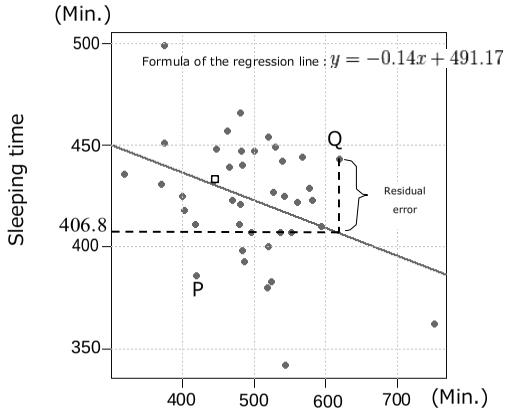


Figure 5 Scatter diagram with the regression line

It was found that there is an overall weak negative correlation between the studying time and the sleeping time across prefectures. Select the most appropriate interpretation of the negative correlation from the following ⓪ to ③. Note that the range of data is considered as the degree of scatter.

ク

⓪ The degree of scatter is considered to be greater for sleeping time than for studying time.
① Sleeping time is considered to be less scattered than studying time.
② Prefectures with longer studying time tend to have shorter sleeping time.
③ Prefectures with longer studying time tend to have longer sleeping time.

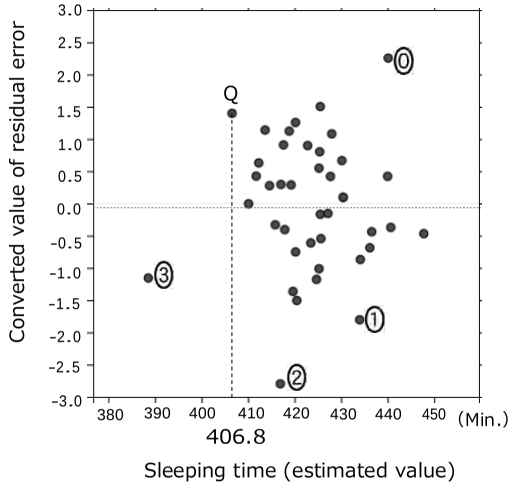


Figure 6 Relationship between sleeping time (estimated value) and converted value of residual error

As can be interpreted from Figures 5 and 6, the number of prefectures that are outliers is [オ], based on the criterion that a value more than twice the standard deviation away from the mean is an outlier. P prefecture in Figure 5 correspond to [カ] of ⓪ to ③ in Figure 6, and Hanako and her peers judged P prefecture to be [キ] according to this criterion. Hanako and her peers considered the influence of other factors besides the studying time and decided to further analyze the characteristics of the prefectures.

Answer group of [キ]

⓪ outlier ① not an outlier
② hard to decide whether it is an outlier or not

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Year: 2023
Edition: First Editon
Publisher: Asia-Pacific Telecommunity
Soi 5, Chaeng Watthana, Thungsonghong, Lak Si, Bangkok 10210, Thailand
Printer: KDDI Foundation
3-10-10, Iidabashi, Chiyoda-ku,
Tokyo 102-8460, Japan

ISBN: 978-4-907714-94-9

ISBN 978-4-907714-94-9
9784907714949

ICT for individually optimized and collaborative learning