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The Prospect of Academic Statistics Education in Japan According to the Results of Essentiality Survey

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In the current age of informatization, data are utilized in every field of society and the need for statistical tools for processing and analyzing these data is more essential than ever. On the other hand, the curriculum for data processing in primary education in Japan lessened because of the introduction of "the relaxed style education" in recent years. Under these circumstances, it is necessary for the statistics education at the university level to bear even greater responsibility in raising qualified personnel to the society.

Seeking future developments of the statistics education at the university level, we conducted the essentiality survey for private enterprises and public institutions in March 2005. We investigated what statistical knowledge are thought to be necessary and how they are being utilized, and whether the current statistics education at the university level is responding to the requirement of society. We will further study the result of this survey to identify the needs of statistics in society and the evaluation of the statistics education at the university level.

Key words: informatization age, statistical knowledge, statistics education at the university level, the essentiality survey

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1. Introduction

In recent years, the circumstances surrounding statistics education has been changed a lot. The Advancement of informatization has mounted up the opportunity of handling data in society. The world is filled to the brim with data and the importance of aptitude for processing and analyzing data is increasingly cognizant of in all areas. Not only manufacturing industries but also service business such as finance and commerce need personnel with certain level of statistical knowledge. In the result, not only students with math and science majors but also liberal arts students are required with skills of using data.

Without appropriate statistical knowledge, much awaited data is not connected with the right problem solving and knowledge discovery. For this reason, in the information society, it is desirable to have the basic statistical knowledge of collecting up the data by oneself. At least, statistical knowledge and capability of handling numerical statistics, tables and graphs are required for all the members of society. For example, even elementary school pupils cannot learn without understanding of the tables or graphs shown in the textbooks. Moreover, people disrupt their everyday life if they cannot calculate the statistical information correctly. Now that, statistical literacy[1)] is the essential and indispensable knowledge of people of today.

Furthermore, inconsiderable huge quantity of the data can be accessed now in advanced information technology and network society. Since those data can produce important intellectual findings if utilized properly, the capability of processing and analyzing of these kind of data comes to be required. That is, it is guessed that the ability of personnel who are needed in society has reached the level of comprehensive, problem-solving type information processing capability. Abilities of not only collecting and analyzing data and information but also voluntarily problem establishment and effective transmission of information are currently required.

On the other hand, in Japan, “decline in academic achievement” has been an issue in the field of education for years. For example, “White paper (investigation report) on lesson improvement in private colleges[2)]” whose investigations were performed at the end of 2004 showed us a part of the current educational situation of Japanese colleges. For “the problem faced in class”, many teachers point out “the fall of basic academic skill” and its degree is increasing. The response rates were 35.3% in 1998, 44.0% in 2001 and 60.1% in 2004 in private senior colleges, and in a similar way, were 43.9%, 55.6% and 66.0% in private junior colleges. Especially, this rate exceeds 70% in the science faculties. Moreover, the indication of “decreased motivation for learning” has also reached to 40%.

Several causes are pointed out for such decrease in academic ability (Okabe et al.(1999), Tose and Nishimura(2001)). One of the most typical incidents is the introduction of “the relaxed style education”, that is the (drastic) mitigation of the contents of Education Ministry guidelines for elementary, junior high and high schools. Because of the relaxed style education, content and time for learning of every subject were lessened. In particular, the influence on statistics education is enormous. Under new educational guidelines, pupils learn arithmetic mean in sixth grade but do not learn any concept of variability in elementary school. As every statistical related item is eliminated from junior high school math course, Japanese students do not learn any concept of variability and distribution in compulsory education. Eliminated items are moved into high school textbooks but the relocation courses (for example, Math B and Math C) are rather minor and choice principle ones. In the result, very few students select statistical related items to learn. As a matter of fact, most Japanese students study little or no statistics after elementary school. (See appendix for details.)

However, graphs and data based descriptions are used more frequently than before in other subjects' textbooks even at the elementary school. Putting above-referenced society trend together, it is concerned that the actual state of school education is a countercurrent against the trend of informatization.

In any case, the statistical knowledge of new students who learned under the new guideline is considered very little. Even science major students do not probably learn statistics since elementary school. In the end, the statistics education at a university may be an almost first experience of respectable statistical learning for a student. In the stream of increment of allergic to mathematics students, university teachers make the best use of inventiveness for their statistics classes[3)], but never feel quite sure if they can bring up students who can contribute to society in proper way.

In order to overthrow such difficult surroundings of statistics education and to pursue the appropriate state of contemporary statistics education, it is necessary to grasp the needs for the statistical knowledge and personnel from the perspective of companies and public organizations and the exact assessment of statistics education at university level.

Although it has been pointed out that the companies require personnel who mastered statistics knowledge (Takeda(1995), Senuma(2004)), it is not fully grasped that which category of companies and organizations need what kind of statistical skills to what extent. Therefore, whether the statistics education in universities can satisfy the needs of society appropriately or not remains a question. Moreover, under the new guideline, whether academic education can fill the gap of weakened primary, junior high, high school education is unclear.

With noted above problem consciousness, we conducted essentiality survey[4)] of data analysis and statistics knowledge intended for companies and public organizations in March 2005. The purpose of this survey is to grasp the needs for the statistics in society from many angles and to aim at the further improvement of the statistics education in universities. Hereafter, the results of the essentiality survey are reported.

2. Outline of essentiality survey "Investigation on the needs of Data Analysis and Statistics Knowledge (Expectation for University Education)"

The outline of the essentiality survey is as follows. We posted questionnaire to the private enterprises that employed more than 1000 people and the public institutions that employed more than 500 people in March 2005. The number of employer is based on *Establishment and Enterprise Census* (statistics Bureau) of 2001 fiscal year. The valid respondents are 302 (184 private companies, 117 public institutions and 1 non-responder). The responding rate is 12%.

Questionnaire entry brings up various topics: attributes of respondents, employment situation, needs for data analysis and statistical knowledge, the evaluation of academic education related to the data analysis, the assessment of the statistical knowledge at the time of adoption or arrangement, regarded qualification, employee education, and so on.

3. Precede Researches and Their results

There were some researches based on questionnaires performed to clarify the needs for mathematics school education. As for all, they concluded that companies evaluate the capability of logical thinking and correct data processing, that is, they think mathematical, especially statistical knowledge indispensable.

Takeda (1995) asked all the listed companies of Tokyo Stock Exchange (1635 companies) from the end of 1991 to February 1992 and obtained 676 respondents (41% of the total, first section 529 companies and second section 147 companies). The type of these companies was various. The average rate of college graduates was about 33% and 13.3% of all the employees needed mathematical knowledge at work. For liberal arts students, 62.7% of the companies adopted mathematics question on the employment examination and 53.1% of the companies felt dissatisfied about the level of mathematical knowledge of recent students. 263 companies (39.1%) wanted students learn basic mathematics in the proper way. On required fields, 190 companies (72.2%) mentioned statistics which ranked first. This tendency does not influenced by the type of business or the department students belong to.

Senuma (2002) conducted the questionnaire investigating the needs of arithmetic and mathematics of society to improve curriculum of these subjects. She mailed all the listed companies of Tokyo Stock Exchange (2060 companies) in the beginning of 2002 and got 399 respondents (19.4% of the total). 48% of the companies thought high school level of mathematics is necessary at work and 25% of the companies thought university level of mathematics is desirable. Inquiring important sub-field, "numbers and calculation", "prediction based on data", "logical thinking" and "statistics" were ranked high. In the end, Senuma also found out that statistical knowledge was indispensable for corporate workers.

Nagasaki (2005) performed the questionnaire to people of extensive and various classes in order to consider the contents of arithmetic and mathematics education. Respondents were 416 researchers (liberal arts 93, physical science and agriculture 86, engineering 58, medicine 78, and the compound domain 101), 333 mathematicians, 53 mathematics educational researchers, 1828 guardians of pupils and students (elementary school 489, junior high school 631, and high school 708), 1901 teachers (elementary school 598, junior high school 474, and high school 829) and 160 supervisors. Respondents were divided 14 groups according to the difference of school type or the field for research. Asking about the importance of various contents of arithmetic and mathematics, items which 80% or more respondents in all the groups were affirmed were “integers and calculation”, “graphs and tables” and “grasping the tendency of data”. In addition, about the importance of various skills of arithmetic and mathematics, 80% or more respondents in all the groups answered “using numbers and figures”, “calculating”, “perceiving tables and graphs”, “communicating one’s idea by using tables and graphs” and “predicting based on obtained data”. It turned out that the statistics related subjects were attached a high value to.

Now, the purpose of the questionnaire we performed is basically the same as precede researches but we focused on statistics and asked many questions about subdivided statistical categories in detail. Moreover, we expanded survey objective compared with Takeda and Senuma. We included not only Tokyo Stock Exchange listed companies but also other stock exchange listed companies and unlisted companies. We also covered public bodies and corporations including central government and local public organizations. We report the obtained results in Section 4.

4. Results of the Investigation

4.1 Attributes of respondents

Within 302 respondents, 184 are private companies and 117 are public organizations (1 respondent does not answer). The breakdown of public organizations are national government: 16 (13.7%), prefecture-run institution: 16 (13.7%), municipal management institution:65 (55.6%) and independent administrative agency:20 (17.1%).

The number of respondents sorting by the size of employee are 15 respondents (private management:13, public management:2) for 299 or less employees, 84 (private:54, public:30) for from 300 to 999 employees, 171 (private:97, public:74) for from 1000 to 4999 employees and 28 (private:19, public:9) for 5000 employees or more.(The number of no answer is 4.)

The type of industry is covered a lot of ground: 10 construction firms, 63 manufacturing, 3 electricity, gas and water services, 9 information and telecommunication, 9 transportation, 6 wholesale, 40 retail, 5 finance and insurance, 1 real estate, 4 restaurant and hotel, 16 medical treatment and welfare, 11 education, 4 compound service, 25 services, 76 official business, and 20 the other (including no answers).

All the 184 private companies are those limited by shares, 69 companies joint the market and 100 companies do not (15 no answer). Checking stock listing, 52 companies join first section of the Tokyo Stock Exchange, 6 second section of the Tokyo Stock Exchange, 1 Osaka Stock Exchange, 1 Nagoya Stock Exchange and 5 companies go on JASDAQ (4 no answer).

Look at the scale of adoption. 273 respondents (private: 168, public: 104, no answer: 5) employed new college graduates in April, 2005. Around 90 percent of both private companies and public organizations did adoption, but 8 respondents (private:4, public:4) did not adopt college graduates.

Within 265 companies which adopted new college graduates, 80 respondents (private: 45, public: 35) took on not over 9 persons, 124 (73, 51) did 10 to 49 persons, 27 (19, 8) did 50 to 99 persons, 21 (18, 2) did 100 to 199 persons, 6 (6, 0) did 200 to 499 persons and 4 (3, 1) did 500 or more persons (3 no answer).

When examining the effect of adoption magnitude in the following analysis, we focus attention to the adoption number of college graduates and use 4 categories classification for adoption scale: none, 1-9 persons, 10-49 persons, and 50 persons or more.

See the breakdown of adopters. 89.3% of the respondents adopted liberal arts course graduates and 81.7% employed science course graduates. More private companies adopted liberal arts graduates than public organizations did (93.3% of private companies, 81.4% of public organizations), and adversely, more public organizations employed science course graduates than private companies did (private: 22.0%, public:36.1%).

Only 202 respondents (66.9%) carried out mid-career recruitment, and public organizations were notably reluctant (private: 83.7%, public:45.3%).

4.2 Needs for the personnel who has knowledge of data analysis and the evaluation for university statistics education

Hereafter, we examine questionnaire results and their features.

(1) Is "the fundamental knowledge" about data analysis or statistics needed at work in your business?

Responses are as follows: "is needed for wide range of work":51 respondents (16.9%), "is needed for some range of work":90 (29.8%), "is useful for work":143 (47.4%), "is not needed at present":17 (5.6%). The difference of private or public and the magnitude of adoption do not effect the tendency of reply. As a whole, 94.1% respondents made the positive assessment.

(2) Is there any business that needs "advanced technical knowledge and capability" about data analysis or statistics at work in your business?

69.9% of respondents answered in affirmative and 25.5% did in negative (no answer: 14). Although the effect of difference between private or public does not observed, the number of affirmative respondents increased as the adoption scale became large (no adoption:3.1%, 1-9 persons:20.0%, 10-49 persons:29.0% and 50 persons or more:37.9%.

We provided following two questionnaire items for investigating the degree of expectation to the knowledge about data analysis or statistics and the evaluation on degree of achievement in university statistics education.

(3) What skill or ability on the fundamental knowledge about data analysis or statistics do you want university graduates to learn?
(4) How about the degree of achievement on the fundamental knowledge in university education?

We provided following 8 sub-categories of statistical knowledge and skill for above mentioned two questions. Answers were got on each type of graduates, arts and sciences.

A. collecting data
B. understanding numerical values in tables and graphs
C. grasping the problem numerically
D. planning investigation/experiment to collect data
E. using PC and processing data
F. conducting data analysis (factor analysis or forecasting)
G. extracting the information from analytical results for problem solving
H. communicating analytical results to others

Results of liberal arts graduates are shown in Table 1 and those of science graduates are shown in Table 2.

From Table 1, we can find most companies and public organizations think statistical knowledge and skill necessary. The essentialities of each sub-category are over 80% except D. planning capability (75.8%). (A. collecting data (87.1%), B. understanding tables and graphs (87.1%), C. grasping the problem numerically (86.8%), E.PC operation capability (88.1%), F. analyzing data(80.5%), G. extracting information from data (86.4%), H. communication skills (89.7%).) The essentialities are especially high for four categories, that is, A. collecting data, B. understanding tables and graphs, E.PC operation capability and H. communication skills. Over 70% of respondents think it is desirable that as many people as possible master these skills. These tendencies do not differ between private companies and public organizations. According to the magnitude of adoption, level of importance varies. Statistical skills are inconsequential for respondents without adoption, in contrast, the degree of required statistical skills was the highest in the companies and organizations who adopted middle-scale (10-49) persons.

Meanwhile, evaluations for the university education to attain these capabilities are not generally high. See the rightmost column of each table. Only the evaluation for E.PC operation capability (56.0%) exceeds 50%. Followed by A. collecting data (48.0%) and B. understanding tables and graphs (46.4%), only around 30% evaluations were obtained for other categories. These evaluations are affected by the type of business. Evaluations by public organizations are higher than those by private companies in every category and the differences are over 10 points in seven categories except H. communication skills. By adoption scale, evaluations for almost all categories except E.PC operation capability are affected distinctly and very high evaluations are seen in the respondents with large-scale (50 or more persons) adoption.

Table 2 shows the results for science graduates. Most companies and public organizations think statistical knowledge and skill indispensable and all the essentialities of each sub-category are over 80% (A. collecting data (88.4%), B. understanding tables and graphs (88.4%), C. grasping the problem numerically (87.7%), D. planning capability (83.1%), E.PC operation capability (88.4%), F. analyzing data(85.8%), G. extracting information from data (86.8%), H. communication skills (88.4%).) That is, over 80% of respondents think it is desirable that as many people as possible master these skills. The essentialities of most categories except H. communication skills are higher than those for arts students. Especially, essentialities for D. planning capability and F. data analyzing ability are remarkably higher. These tendencies do not differ between private companies and public organizations. According to the magnitude of adoption, level of importance escalates with more the number of new recruits. Essentialities are extremely high and over 90% for respondents with large number of new recruits.

Although the evaluation for university education are evidently low compared with the degree of essentiality as well as a liberal arts students' case, the evaluations for the statistical skills for science graduates are considerably higher than those for arts graduates in all categories. 60% of the companies and organizations accepted the degree of achievement of university graduates for A. collecting data, B. understanding tables and graphs and E.PC operation capability. However, even for scientific graduates, the degree of attainment for four categories (D. planning capability, F. analyzing data, G. extracting information from data and H. communication skills) does not exceed 50%. In most cases, evaluations by public organizations are higher than those by private companies. Besides, evaluations by the respondents with large-scale (50 or more persons) adoption are higher in every category.

Table 1 The necessity of the statistical skill and the evaluation of the statistical education (Liberal arts graduates)

(Upper stand value is number of case, lower stand value is its percentage.)

A. Abilities to collect data

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	218	45	263	145
	72.2	14.9	87.1	48.0
private companies	133	29	162	81
	72.3	15.8	88.0	44.0
public organizasions	85	15	100	64
	72.6	12.8	85.5	54.7
adopt no graduates	18	8	26	15
	56.3	25.0	81.3	46.9
adopt 1 to 9 persons	52	12	64	37
	65.0	15.0	80.0	46.3
adopt 10 to 49 persons	98	12	110	57
	79.0	9.7	88.7	46.0
adopt 50 or more persons	45	11	56	33
	77.6	19.0	96.6	56.9

B. Abilities to understand tables and graphs

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	218	45	263	140
	72.2	14.9	87.1	46.4
private companies	136	26	162	78
	73.9	14.1	88.0	42.4
public organizasions	82	18	100	61
	70.1	15.4	85.5	52.1
adopt no graduates	20	6	26	14
	62.5	18.8	81.3	43.8
adopt 1 to 9 persons	50	14	64	34
	62.5	17.5	80.0	42.5
adopt 10 to 49 persons	96	15	111	54
	77.4	12.1	89.5	43.5
adopt 50 or more persons	46	9	55	35
	79.3	15.5	94.8	60.3

C. Abilities to grasp the problem quantitatively

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	198	64	262	106
	65.6	21.2	86.8	35.1
private companies	127	36	163	53
	69.0	19.6	88.6	28.8
public organizasions	71	27	98	53
	60.7	23.1	83.8	45.3
adopt no graduates	14	13	27	11
	43.8	40.6	84.4	34.4
adopt 1 to 9 persons	48	17	65	27
	60.0	21.3	81.3	33.8
adopt 10 to 49 persons	88	20	108	37
	71.0	16.1	87.1	29.8
adopt 50 or more persons	43	12	55	29
	74.1	20.7	94.8	50.0

D. Abilities to plan investigation/experiment

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	148	81	229	93
	49.0	26.8	75.8	30.8
private companies	82	51	133	49
	44.6	27.7	72.3	26.6
public organizasions	66	29	95	44
	56.4	24.8	81.2	37.6
adopt no graduates	8	16	24	9
	25.0	50.0	75.0	28.1
adopt 1 to 9 persons	33	22	55	26
	41.3	27.5	68.8	32.5
adopt 10 to 49 persons	71	24	95	33
	57.3	19.4	76.6	26.6
adopt 50 or more persons	30	18	48	23
	51.7	31.0	82.8	39.7

E. Abilities to use PC and process data

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	235	31	266	169
	77.8	10.3	88.1	56.0
private companies	142	24	166	94
	77.2	13.0	90.2	51.1
public organizasions	93	6	99	75
	79.5	5.1	84.6	64.1
adopt no graduates	23	4	27	15
	71.9	12.5	84.4	46.9
adopt 1 to 9 persons	60	7	67	44
	75.0	8.8	83.8	55.0
adopt 10 to 49 persons	99	10	109	74
	79.8	8.1	87.9	59.7
adopt 50 or more persons	46	10	56	34
	79.3	17.2	96.6	58.6

F. Abilities to do data analysis

	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	124	119	243	92
	41.1	39.4	80.5	30.5
private companies	70	81	151	49
	38.0	44.0	82.1	26.6
public organizasions	54	37	91	43
	46.2	31.6	77.8	36.8
adopt no graduates	8	17	25	9
	25.0	53.1	78.1	28.1
adopt 1 to 9 persons	33	26	59	25
	41.3	32.5	73.8	31.3
adopt 10 to 49 persons	57	41	98	31
	46.0	33.1	79.0	25.0
adopt 50 or more persons	23	31	54	26
	39.7	53.4	93.1	44.8

Table 1 (continued from previous page)

	G. Abilities to extract the meaning from results				H. Abilities to communicate results to others			
	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	173	88	261	84	227	44	271	96
	57.3	29.1	86.4	27.8	75.2	14.6	89.7	31.8
private companies	108	56	164	44	143	28	171	57
	58.7	30.4	89.1	23.9	77.7	15.2	92.9	31.0
public organizasions	65	31	96	40	84	15	99	39
	55.6	26.5	82.1	34.2	71.8	12.8	84.6	33.3
adopt no graduates	13	14	27	7	17	10	27	8
	40.6	43.8	84.4	21.9	53.1	31.3	84.4	25.0
adopt 1 to 9 persons	38	27	65	27	54	15	69	24
	47.5	33.8	81.3	33.8	67.5	18.8	86.3	30.0
adopt 10 to 49 persons	80	27	107	24	101	10	111	33
	64.5	21.8	86.3	19.4	81.5	8.1	89.5	26.6
adopt 50 or more persons	38	17	55	24	49	8	57	30
	65.5	29.3	94.8	41.4	84.5	13.8	98.3	51.7

Table 2 The necessity of the statistical skill and the evaluation of the statistical education (Science graduates)

(Upper stand value is number of case, lower stand value is its percentage.)

	A. Abilities to collect data				B. Abilities to understand tables and graphs			
	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	245	22	267	180	242	25	267	184
	81.1	7.3	88.4	59.6	80.1	8.3	88.4	60.9
private companies	153	11	164	110	149	15	164	110
	83.2	6.0	89.1	59.8	81.0	8.2	89.1	59.8
public organizasions	91	11	102	69	92	10	102	73
	77.8	9.4	87.2	59.0	78.6	8.5	87.2	62.4
adopt no graduates	23	1	24	17	24	1	25	18
	71.9	3.1	75.0	53.1	75.0	3.1	78.1	56.3
adopt 1 to 9 persons	63	4	67	50	59	8	67	48
	78.8	5.0	83.8	62.5	73.8	10.0	83.8	60.0
adopt 10 to 49 persons	101	11	112	70	100	12	112	71
	81.5	8.9	90.3	56.5	80.6	9.7	90.3	57.3
adopt 50 or more persons	54	3	57	41	52	4	56	45
	93.1	5.2	98.3	70.7	89.7	6.9	96.6	77.6

Table 2 (continued from previous page)

	C. Abilities to grasp the problem quantitatively				D. Abilities to plan investigation/experiment			
	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	235	30	265	159	199	52	251	127
	77.8	9.9	87.7	52.6	65.9	17.2	83.1	42.1
private companies	143	21	164	93	118	34	152	73
	77.7	11.4	89.1	50.5	64.1	18.5	82.6	39.7
public organizasions	91	9	100	65	80	18	98	53
	77.8	7.7	85.5	55.6	68.4	15.4	83.8	45.3
adopt no graduates	23	2	25	16	17	7	24	12
	71.9	6.3	78.1	50.0	53.1	21.9	75.0	37.5
adopt 1 to 9 persons	60	8	68	41	49	14	63	37
	75.0	10.0	85.0	51.3	61.3	17.5	78.8	46.3
adopt 10 to 49 persons	96	12	108	61	86	18	104	43
	77.4	9.7	87.1	49.2	69.4	14.5	83.9	34.7
adopt 50 or more persons	50	7	57	39	42	11	53	34
	86.2	12.1	98.3	67.2	72.4	19.0	91.4	58.6

	E. Abilities to use PC and process data				F. Abilities to do data analysis			
	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	249	18	267	195	196	63	259	139
	82.5	6.0	88.4	64.6	64.9	20.9	85.8	46.0
private companies	149	15	164	114	118	42	160	79
	81.0	8.2	89.1	62.0	64.1	22.8	87.0	42.9
public organizasions	99	3	102	80	77	21	98	59
	84.6	2.6	87.2	68.4	65.8	17.9	83.8	50.4
adopt no graduates	24	1	25	16	18	7	25	13
	75.0	3.1	78.1	50.0	56.3	21.9	78.1	40.6
adopt 1 to 9 persons	64	4	68	53	47	18	65	37
	80.0	5.0	85.0	66.3	58.8	22.5	81.3	46.3
adopt 10 to 49 persons	104	7	111	79	84	21	105	56
	83.9	5.6	89.5	63.7	67.7	16.9	84.7	45.2
adopt 50 or more persons	50	6	56	45	42	15	57	32
	86.2	10.3	96.6	77.6	72.4	25.9	98.3	55.2

	G. Abilities to extract the meaning from results				H. Abilities to communicate results to others			
	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education	necessary for as many graduates as possible	nessesary for some graduates	(sum total of 'necessary')	performance evaluation for university education
All respondents	213	49	262	128	239	28	267	119
	70.5	16.2	86.8	42.4	79.1	9.3	88.4	39.4
private companies	133	30	163	73	147	18	165	67
	72.3	16.3	88.6	39.7	79.9	9.8	89.7	36.4
public organizasions	79	19	98	54	91	10	101	51
	67.5	16.2	83.8	46.2	77.8	8.5	86.3	43.6
adopt no graduates	20	5	25	12	22	3	25	11
	62.5	15.6	78.1	37.5	68.8	9.4	78.1	34.4
adopt 1 to 9 persons	50	16	66	38	58	9	67	32
	62.5	20.0	82.5	47.5	72.5	11.3	83.8	40.0
adopt 10 to 49 persons	91	17	108	46	103	8	111	45
	73.4	13.7	87.1	37.1	83.1	6.5	89.5	36.3
adopt 50 or more persons	49	7	56	32	51	6	57	31
	84.5	12.1	96.6	55.2	87.9	10.3	98.3	53.4

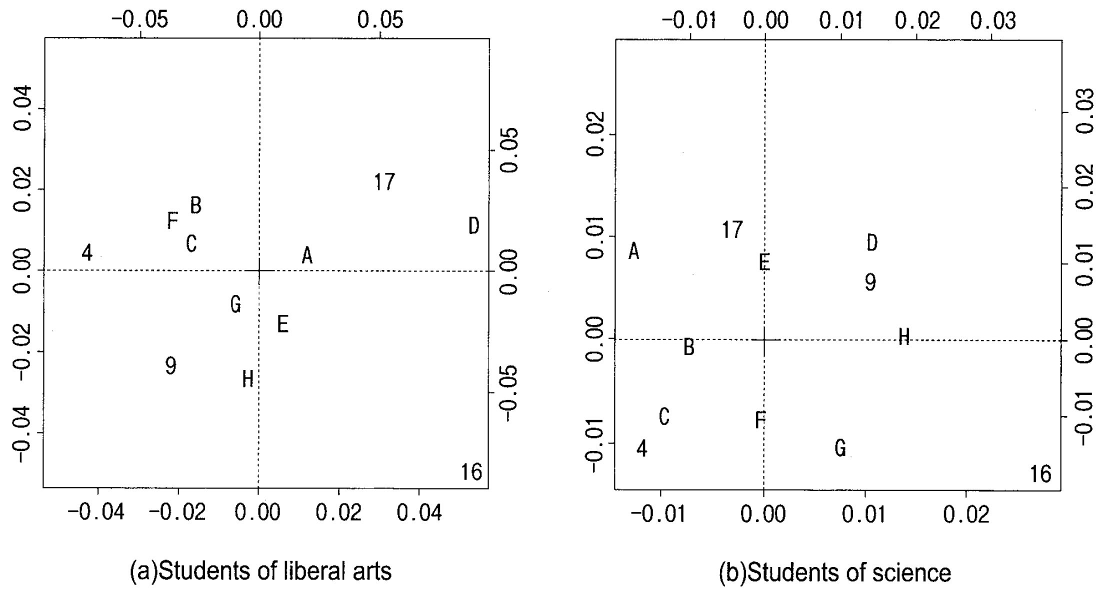
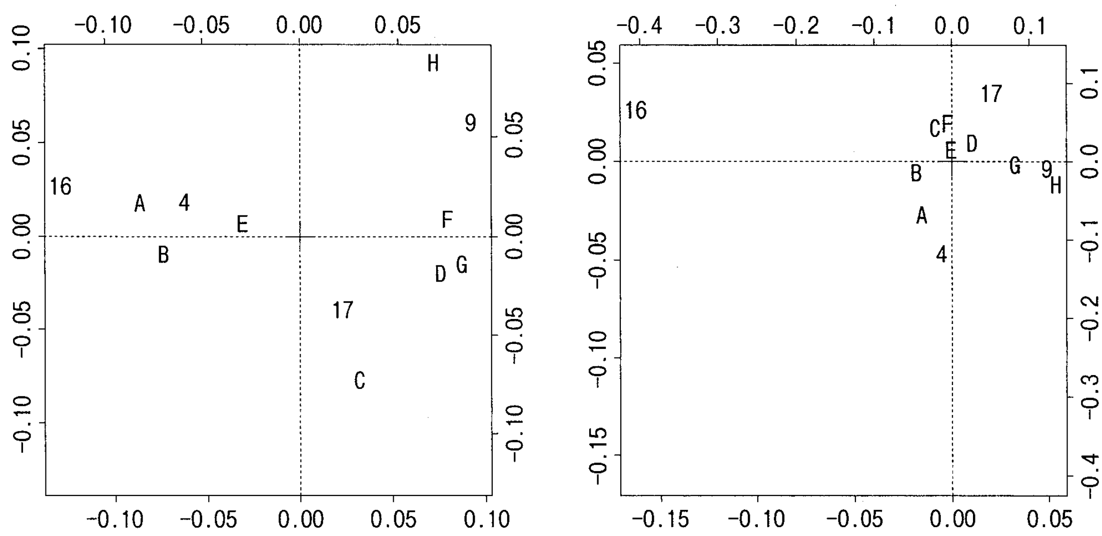


Figure 1 Useful statistical knowledge by the type of industries
(Numbers indicate industries. 4: manufacturing, 9: retail trade, 16: services, 17: public institutions. Alphabets show subdivided statistical skills.)

Now, do the essentialities of expected categories of statistical skill and the evaluation of degree of achievement in university education differ by the type of industry? As the number of reply was not so large in this survey, we picked up some industries with considerable number of answer and to examine these points via correspondence analysis. Four Industries taken up for analysis are 4. manufacturing, 9. retail, 16. service, and 17. official businesses.

The result about "what type of statistical knowledge is expected" is shown in Fig. 1. For both arts graduate case (Fig. 1 (a)) and science graduate case (Fig. 1 (b)), contribution ratios up to the second axes are around 90% (about 60% for the 1st axis and 30% for the 2nd axis). Although the values of the scale of axes are not so large, four types of industry are arranged on a plane with different characteristics and it proves that their needs are different respectively. For arts graduates, 4.manufacturing industry weighs B. understanding tables and graphs,



(a)Students of liberal arts

(b)Students of science

Figure 2 Performance evaluation of academic education by the type of industries

(Numbers indicate industries. 4: manufacturing, 9: retail trade, 16: services, 17: public institutions. Alphabets show subdivided statistical skills.)

C.grasping the problem numerically and F. analyzing data ability heavily. 9. Retail industry values H. communication skills and 17.public business emphasizes D. planning capability. Other skills, A. data collection capability, E.PC operation capability, and G. extracting information from data capability are generally needed in every type of industry. On the other hand, for science graduates, 4. manufacturing industry stresses C. grasping the problem numerically capability, following B. understanding tables and graphs and F. analyzing data abilities. 9. Retail industry requires D. planning capability, 17. public business thinks E.PC operation capability as important and the needs for G. extracting information from data capability is seen in 16. service industry.

The result about "the degree of achievement in university education" is shown in Fig. 2. For both arts graduate case (Fig. 2 (a)) and science graduate case (Fig. 2 (b)), the contribution to two axes is 85 to 90% (about 65% for 1st axis and 25 to 30% for 2nd axis). For science graduates, four types of industry are arranged as different place on a plane with different features. By the way, skills of sub-categories in Fig. 2 (b) look to concentrate to the origin, but the scale of this graph is rather large and the variation in each capability is comparable as one in other graphs. To put it the other way around, the position of 16. service industry in Fig. 2 (b) differs to a great extent from others. Among eight capabilities, 4. manufacturing industry emphasizes A. data collection capability, 9. retail does H. communications skills. On the other hand, for liberal arts graduates, evaluations by 4. manufacturing industry and 16. service industry are similar and different from those by 9. retail and 17. public business. 4. The manufacturing industry and 16. service industry put much faith in A. data collection and B. tables/graphs reading capability, meanwhile, 9. retail trade emphasizes H. communications skills and 17. official business stresses C. grasping the problem numerically.

(5) What do you think about the necessity of university mathematics education?

Although questionnaires in this survey were mainly focused on data analysis and statistics, we asked necessities of over across the board mathematics in this entry.

For arts students, replies are 'study fundamental knowledge exactly' (23.8%), 'basic (general culture course's level of) knowledge may be sufficient' (61.9%) and 'elementary (high school's level of) knowledge is sufficient, no need for university mathematics education' (9.3%). This result is hardly influenced by management figuration (whether the respondent is a private company or a public organization) and the adoption scale.

On the other hand, for science graduates, most respondents think that appropriate mathematical knowledge is required for them (71.2%; considerable level: 15.9%, decent level: 55.3%). This tendency is higher in private companies (private: 77.2%, public: 61.5%). According to adoption scale, the degree of necessity becomes high as adoption scale is large and the strong essentiality is observed in the company which adopted large-scale (50 or more) persons (84.5%).

(6) Then, what subject of mathematics is required for? (multiple answers allowed)

For arts students, the reply of 'statistics' (76.4%; private: 82.2%, public: 66.7%) is overwhelmingly abounding and exceeds second place 'computational mathematics (programming etc.)' (25.0%; private:28.9%, public:18.5%) in a large way. This topping tendency of statistics does not affected by the adoption scale. The rate of other replies, such as 'differentiation and integral calculus', 'linear algebra', and 'planning mathematics' are just over or below 10%.

For science graduates, the necessity of statistics is still high (60.9%) but the differences with other categories are contracted. Second place category is 'computational mathematics' (36.8%). The essentiality of statistics for science graduates does not affected by the management type. About the scale of adoption, that the statistics essentiality is very high even in companies/organizations without adoption (75.0%) is attracted attention to.

(7) Which orientation shall be go after as university education on data analysis and statistics as fundamental knowledge, "basic theory" or "application"?

The ratio of no answer was rather high in this question (6.0%). In the absence of nonresponders, about 40 percent of the rest respondents chose "to teach focusing on basic theory or a statistical view", and about 60 percent chose "to teach focusing on the application to an actual problem." This ratio hardly shows any change via management type and adoption scale of respondents.

4.3 Evaluation of the knowledge on data analysis and statistics at the time of adoption or arrangement

It becomes clear that many companies and organizations have recognition that data analysis and statistics knowledge are indispensable for their work. In this section, we try to clarify whether these recognitions are efficiently employed for fresh hiring and office change of positions.

(8) Is there any qualification of data analysis or in connection with information technology (IT) to be attached a high value to? (multiple answers allowed)

The respondents of this question are 262 companies that employed the college new graduates. Unfortunately, the response rate is low (no answer: 74.8%) and several companies/organizations wrote that they gave little thought of qualifications for hiring in the free answer column. Qualifications that the number of replies are over double figures are: system administrator (15 affairs), an Information Technology Engineer I kind (15), Software Design and Development Engineer (12), and a Senior Systems Administrator (10).

(9) Is the degree of consideration for skill, experience, and knowledge increasing than before on adoption of mid-carrier worker?

Within 154 private companies that conducted mid-carrier recruiting, 70.8% of the companies answered affirmatively. Although most of the public organizations did not accept mid-carrier workers (q.v. section 4.1), the half of 48 organizations that recruited mid-career workers answered in affirmative.

(10) What kind of thing is taken into considerations, when arranging the faculty graduates at work that needs "the fundamental knowledge" about data analysis or statistics? (multiple answers allowed)

The respondents of this question are 141 companies/organizations (private: 86, public: 55) which answered question (1) affirmatively. About 10% of no answers were found both for private companies and public organizations. From the result (unit: %) shown in the following table, "interview" is counted as a whole and this tendency is particularly high in the private companies. The answer of "numerical ability test at employment" amounts to one-thirds in the private companies, but only about 5% of public organizations conduct these pre-employment examinations. Most private companies do not consider college experience of studying statistics or majoring in the subject or field, while public organizations evaluate these things more applicable than a "numerical ability test".

	major related fields	take related classes	numerical ablity test at recruiting	interview	do not arrange new graduates
All respondents	10.6	12.8	22.7	44.0	5.0
private companies	10.5	15.1	33.7	51.2	5.8
public organizations	10.9	9.1	5.5	32.7	3.6

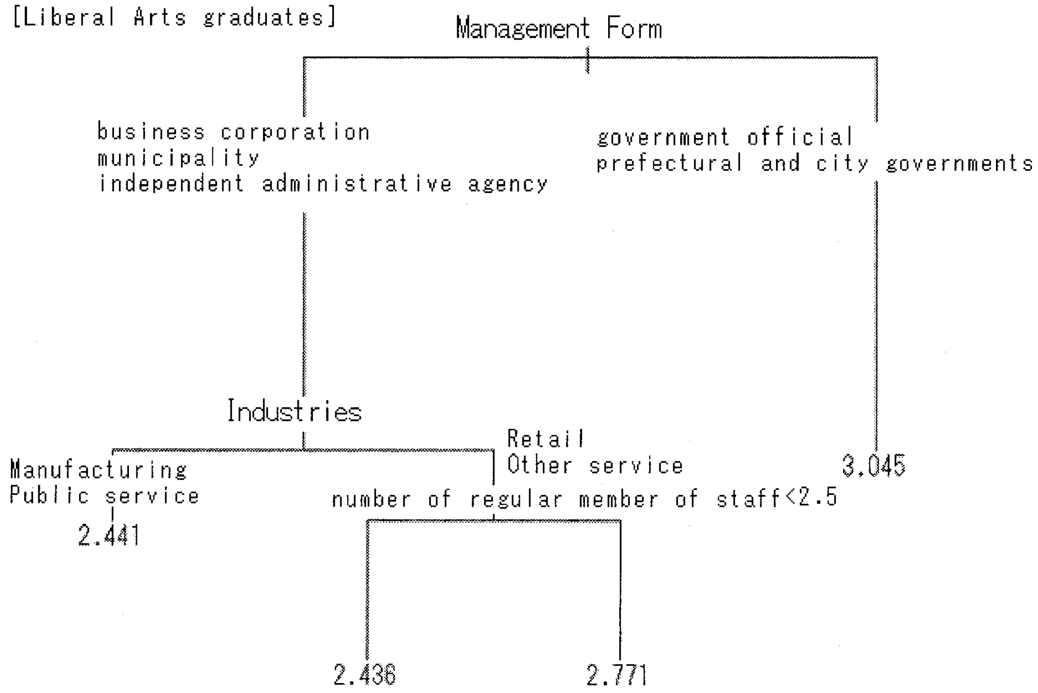
(11) How do you arrange personnel for the work that needs "the advanced knowledge" about data analysis or statistics? (multiple answers allowed)

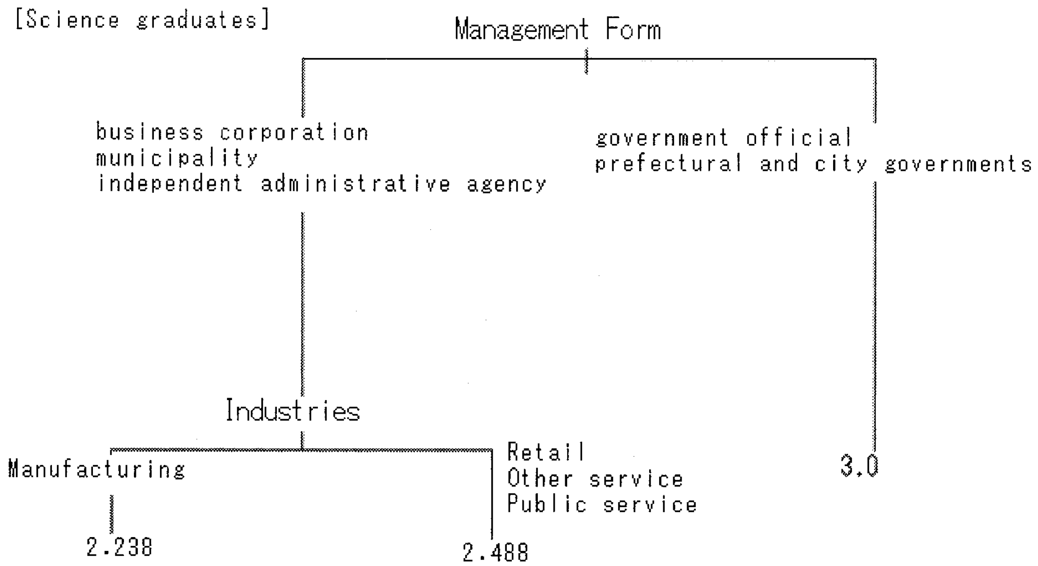
The respondents of this question are 77 companies/organizations (private: 47, public: 30) which answered question (2) affirmatively. The ratios of no answers are 13.3% for private companies and 4.3% for public organizations. From the result (multiple answers, unit:%) shown in the following table, about 70 percent of companies and public organizations carried out the method that "search appropriate personnel regardless of educational background and reshuffle the personnel in the company". In public organizations, it is very rare to put a new graduate into that kind of position as compared to private companies. Although about one-thirds of private companies used mid-career recruitment, public organizations seldom or never conducted intermediate recruiting.

	arrange new graduates	arrange new graduates (graduate students)	relocate internal appropriate person	intermediate recruitment for practician	using temp service and unit contract
All respondents	19.5	22.1	66.2	22.1	2.6
private companies	25.5	31.9	63.8	34.0	4.3
public organizations	10.0	6.7	70.0	3.3	−

As some differences were observed in both the essentiality of statistical knowledge and the achievement degree of university education by industry, we used tree model and exmined the industrial difference of the evaluation for statistical knowledge at hiring and posting. (In the figure below, smaller values mean significant concern about statistical knowledge.)

From the figure, it is clarified that: 1) Federal offices and prefectural and city governments think statistics knowledge less important when hiring, 2)In private companies, the manufacturing industry puts more faith into statistics than other industries do, 3) In retail and service industries, companies with few employees think much of statistical knowledge at changing of position.





(12) When the universities certify the skills of data analysis and statistical skills and knowledge based on school credits, do you consider it at the hiring or posting arrangement?

53.0% (private: 54.9%, public: 50.4%) respondents answered affirmatively for arts students, and 61.9% (private: 63.6%, public: 59.0%) for science students. Seeing the adoption scale, the ratio of affirmativeness is high for the companies/organizations without a new hire (65.6% for arts students and 68.8% for science students) and low for the companies that performed large-scale (50 or more persons) adoption (43.1% for arts students and 55.2% for science students).

(13) What kind of employee education is carried out in your company or organization to improve the capability of data analysis or to acquisite statistics knowledge? (multiple answers allowed)

The reply result is shown in the following table. Most common answers are OJT (on-site training) and it is over the majority in private companies. It is followed by "spontaneous study", "dispatch to external seminars", "set training", "correspondent education". Around 30 percent of companies and organizations answered these items respectively. However, the reply of "no education in particular, nothing is carrying out" is also seen for about 25% companies and organizations regardless of management type. This tendency becomes weak as the adoption magnitude turns up.

	set training	dispatch to external seminars	dispatch to external research institutes	corre-spondent education	OJT	spontane-ous study	other	nothing
All respondents	26.8	31.1	4.0	23.8	50.3	32.8	1.7	24.5
private companies	28.3	33.7	2.7	28.8	55.4	34.2	1.1	24.5
public organizations	24.8	27.4	6.0	16.2	42.7	30.8	2.6	24.8
adopt no university graduates	12.5	28.1	–	15.6	34.4	25.0	–	46.9
adopt 1 to 9 persons	16.3	31.3	1.3	16.3	41.3	26.3	2.5	33.8
adopt 10 to 49 persons	31.5	31.5	5.6	24.2	55.6	36.3	0.8	20.2
adopt 50 persons or more	37.9	32.8	5.2	39.7	62.1	39.7	1.7	10.3

4.4 Evaluation to the knowledge of statistics in free description column

Finally, examine description in free column for the frank view of companies and organizations. In broad terms, there are two contents were pointed out.

One is the indication about students' knowledge "are just formal wisdom and cannot be used in practice". Similar opinions used expressions of "application capability is missing" and "useful data processing cannot be performed". These opinions go along with the result of question (7) of section 4.2 that shows the significant concern for applied aspect exceeded the need for "basic theory".

In order to learn application capability, the strong request of "teach students firmly about the connection with other subjects and how statistics amounted to much in the society" and "teach the reason why statistics is required and raise their motivation" were brought out.

Moreover, very severe voice was also brought out for entire university education. "Although statistics and mathematics are indispensable, doesn't the ability of logical thinking precede before saying the necessity of these skills? The number of student who cannot think logically increases." "It seems that the ability to think in itself deteriorated. Students liable to depend on manuals and do not think through by themselves. This tendency is especially observed for arts students."

These comments are very harsh but represent what we feel for students on a daily basis very straightforwardly. It is necessary to rebuild statistics education in universities to meet these requests without any loss of time.

5. Conclusion and remaining issues

We conducted the essential survey for private companies and public institutions in March 2005. The purpose of our research is to investigate the demand for data analysis and statistics knowledge and the expectation and evaluation for the statistics education at the university level.

As this survey was conducted at a peak season of the end of a fiscal year, the collect rate was not high. Although this flaw should be taken into consideration, the result of the questionnaire agrees with those of precedence researches and provides further knowledge from its broad coverage and questionnaires with a focus on statistics.

In essentiality survey, we asked various items, such as adoption, education and evaluation of respondents' employees. Chief results related statistics education are as follows:

1) Most respondents (private enterprises and public institutions) think statistical knowledge is essential to their business. 46.7% of respondents think basic statistical skill is necessary and 94.1% of respondents think it useful for their business. In addition, 25.5% of respondents think their employees have advanced statistical knowledge is desirable.

2) We subdivided the ability about the data processing into 8 categories and asked respondents whether they think (i) these skills are necessary to their business and (ii) these knowledge are achieved by the statistics education at the university level. From Table 1 and Table 2, the strong needs for wide-ranging statistical skills are evident, while the degree of achievement at the present level of statistics education in universities is not sufficient.

3) By correspondence analysis, we find out statistical knowledge considered useful for business is different by the type of industry. Moreover, by tree analysis, there showed the level of importance on statistical knowledge is also different by the category of business.

These propensities are despite whether respondents are public or private. So, most private companies and public institutions evaluate the statistical knowledge, while they are not very satisfied with the statistics education in universities. In fact, comments in the opinion column show more concrete and demanding requests. Some respondents criticize the statistical knowledge of students is rather superficial and cannot be expanded in application. They ask more adaptable and practical potentials to the future employees.

Achievements evaluated by companies and institutions show that the level of statistical literacy of Japanese university students is precarious. However, the socially desirable statistical skills and abilities are higher and more pragmatic. Statistics education in university that can provide more contemporary statistical knowledge and skills for responding to reality are awaited. Responding to these needs, that is, the pursuit of statistical thinking and reasoning without delay is the challenges of the future for Japanese statistics education.

Although praising the importance of statistical skills and knowledge highly, most companies and public organizations do not very consider learning in universities especially at the time of adoption and arrangement. It looks like somewhat double standard, but the above-mentioned evaluation to the degree of achievement in university education and opinions in free descriptive column verify the problem of the present university education.

Nowadays, the Ministry of Education finally indicates reexamining of relaxed style of education (Brand-new guidelines are scheduled to announce in March, 2008). Not only at universities but also at elementary, junior high and high schools, educational shakeout is an urgent issue. University teachers should beneficially assist those movements and also improve statistical education in universities markedly.

Appendix: relaxed style of education

The contents studied in the primary schools, junior and senior high schools in Japan are determined by the government guidelines for teaching, the standard of curriculum which Ministry of Education, Culture, Sports, Science and Technology gives notice. It applies to all the schools and has especially strong binding force to public schools. In general, revisions have been performed around every ten years.

For postwar 30 years, Japanese curriculum had been enhanced. However, the modernization curriculum had begun to offer without sufficient preparation in 1971 fiscal year for elementary school. After a while, there appeared many students left behind. Spurring by the overcharged competition to get into university, burnout syndromes of young people became an object of public concern. This made Central Education Council that composed school curriculum guideline put forward the idea of reducing the content of school lessons in 1976. Henceforth, Japan moves to the era of pressure-free education.

The 1980 fiscal year curriculum slightly reduced the contents of each subject. The 1992 fiscal year guidelines which ensure individuality via 'New Concept of Scholastic Ability' lessoned further content of learning. However, the tendency of decline in academic achievement came to be seen regardless of the field at the mid-90s and there appeared the opposite view. When the following revised guideline was set forth, strong criticism occurred in the educational world. The opposition movement was particularly fierce in math and science. But new guidelines were moved to enforcement in 2002 fiscal year.

New guidelines aim at developing the power of the living and relaxed style of education. Because of full transition to a five-day school week and introduction of period of integrated learning, the content of school lessons of every subjects reduced by 30% without exception. Statistics curriculum that was taught in mathematics course was drastically reduced. Present statistics contents under the new guidelines are:

Elementary school: bar graph (3rd grade), line graph (4th grade), circle graph (5th grade) and arithmetic average (6th grade)

Junior high school: foundation of probability (1st grade)

High school: Some contents placed in Mathematics B and Mathematics C courses.

However, in high school, those two courses are rather minor within seven courses of mathematics. Moreover, they are credit-system courses and students select voluntary two items to study from four items of textbook. As almost all students choose basic mathematics items not statistical ones, in the end, statistics contents are hardly ever learned in high school.

As a result, a college student who learned under the new guidelines probably does not know even the concept of variation and has hardly any statistical knowledge, even if he/she is a science student.

Now, do these immoderate curtailments go with the flow of the times? Are they in true with another countries' movements? Is there any (ill) effect on students' academic ability?

It is with regret that we have nothing left to say except this direction of reducing (statistical) school contents runs counter to the trend of the world. At the same time, the rating of Japan by the result of international achievement investigation has slipped off.

PISA is a triennial cross-national study achievement investigation of OECD. It started in 2000 and several dozen of nations participated. This survey objects 15 years old students and three fields (reading ability, mathematical literacy and scientific literacy) at bottom. In 2000, just after the start of the new guidelines, the ranking of Japan was the 8th place of reading ability, the 1st place of mathematical literacy and the 2nd place of scientific literacy. They were climbed down in 2003 (the 14th, the 6th and the 2nd place, in order) and went down much further in 2006. Meanwhile, from a viewpoint of statistics education, detailed sub-categories analysis within mathematical literacy of 2003 brought us still more shocking results. Although Japan placed the 6th place for mathematical literacy on the whole and made strenuous efforts in two categories (2nd place for "space and form" and 7th place for "change and relation"), some ranking of sub-categories reconciled to the 2nd group (11th place for "quantity" and 9th place for "uncertainty" which deals statistics knowledge).

The result of another international comparison, the international mathematics and science educational-trends investigation (TIMSS) by International Association for the Evaluation of Educational Achievement (IEA) indicates similar tendencies. In this quadrennial survey, several dozen of nations participated and 10 years old and 14 years old pupils/students are investigated. Although the result of the arithmetic for elementary school pupils only fell by 0.2 point in 2003 compared even with 1995 one, the result of mathematics for junior high school students fell 4 point compared with 99 one. Examined in detail, the performance of sub-categories except "geometry", that is, "number", "algebra", "measurement" and "expression and analysis of data, probability" fell off clearly. In addition, the coverage rate of Japanese junior high school curriculum to the setup problems were 77% for "geometry", 100% for "number" and "algebra", 88% for "measurement" and 38% for "expression and analysis of data, probability". Obviously, the present situation of Japanese statistics curriculum has (huge) troubles.

With these successive results and aroused public opinion, Ministry of Education finally is in a fair way to convert their policy. At last, Central Education Council admitted that the relaxed education policy has some disadvantage and decided increment of course hour for the first time in three decades in September 2007. Although the details of reformation does not specified yet (A new outline is scheduled to announce in March, 2008), these change are thought of as some promising sign for statistics education in schools.

Notes

1) Statistical literacy is defined as "the capability giving a suitable understanding and clear evaluation to the argument based on data (analysis)", and "the ability of establishing communication and making decisions based on data (analysis) ". (Gal, 2002).

2) Japan Universities Association for Computer Education has conducted this survey every three years since 1998 fiscal year. Results are available at http:// www.juce.jp/LINK/report/ report2.htm.
   The number of respondents in 2004 was 25,521 private senior college teachers (38% of all the private senior college teachers) and 2,347 junior college teachers (22% of all the private junior college teachers).
3) For example, utilizing the Web and pulling out students' interest proved to be effective (Watanabe (2004)).
4) This investigation was conducted by the research group on scientific research fund (subject number:14380126, research representative:Masakatsu Murakami, Doshisha University) and the statistics education committee of the Japan Statistical Society (then chairman: Michiko Watanabe, Toyo University).

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