STATISTICAL EDUCATION IN DEPARTMENT OF INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING OF WASEDA UNIVERSITY

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Industrial and management systems engineering is an academic field in designing, constructing, operating, managing, and utilizing functional systems in society such as production, logistics, transportation, information communication, and service. In the department at Waseda University, we consider these functional systems as the targets of research and education, and five viewpoints, "quality," "time," "profit," "human," and "environment" are set as the evaluation axes. In recent years, the need for data scientists is rising. It is said that three skills are required for the data scientist, namely: business skills, IT skills, and statistical analysis skills. This paper explains that if students in our department take elective subjects properly and then graduate research in a laboratory specializing in statistics, they will be able to master the three skills necessary for data scientists to a high level.

INTRODUCTION

Waseda University, along with Keio University, has been recognized as a leading private university in Japan. In particular, Waseda University founded the first faculty of science and engineering in Japan and has also focused on human resources education in science and technology.

Tokyo Senmon Gakko (Tokyo College), the predecessor of Waseda University, was founded in 1882 by Shigenobu Okuma. It was subsequently renamed Waseda University in 1902. In 1909, School of Science and Engineering, the predecessor of Faculty of Science and Engineering, was established. In 1920, Faculty of Science and Engineering was ratified.

In 1943, Industrial Management Department was established in School of Science and Engineering at Waseda University. In 1996, it was renamed Department of Industrial and Management Systems Engineering.

Waseda University holds its founding principles: "the preservation of the independence of scholarship," "the promotion of the practical application of scholarship," and "the fostering of good citizens" (https://www.waseda.jp/top/en/about/work). Faculty members at Waseda University conduct research and education with these principles in mind.

In this paper, we introduce statistical education in Department of Industrial and Management Systems Engineering of Waseda University. In the next section, we explain our department. In the third section, we describe the statistical education of our department. In the final section, we provide conclusions.

DEPARTMENT OF INDUSTRIAL AND MANAGEMENT SYSTEMS ENGINEERING OF WASEDA UNIVERSITY

Industrial and management systems engineering is an academic field for designing, constructing, operating, managing, and utilizing functional systems in society such as production, logistics, transportation, information communication, and service. It can be said that it is the field where "the promotion of the practical application of scholarship" of Waseda University's founding principles stated in the previous section is particularly emphasized.

Department of Industrial and Management Systems Engineering of Waseda University aims to develop human resources capable of contributing to the achievement of various management objectives, problem identification, and problem solving, including responses to the information society, efforts to address environmental problems, and realization of organizational management that will be competitive in the international community.

Accordingly, in our department, the above-mentioned functional systems in society are considered as the targets of research and education, and five criteria: "quality," "time," "profit,"

"humans," and "the environment" are set as the evaluation axes. "Statistical science," "mathematical science," "information technology," and "system technology" are then applied.

As described above, the task of Department of Industrial and Management Systems Engineering is to solve the management problems of the organization through engineering.

Owing to the term "management," it is sometimes considered that our department is not strongly related to mathematics and engineering, but this is not the case. It is a comprehensive science and engineering department. Mathematics and information technology are necessary for research in our department. And, actually, students who are good at mathematics enroll in our department. In our department, since 1997, all new students have been asked to purchase laptop computers, and education in using them has been undertaken. Such an initiative was the first among the 14 departments of Waseda University's Faculty of Science and Engineering, at that time.

Table 1. The specialized education subjects of Department of Industrial and Management Systems Engineering of Waseda University
(http://www.mgmt.waseda.ac.jp/)

1st year	*Statistical Analysis*, Statistical Analysis Workshop**, Introductory Experiments of Ind. & Mgmt. Sys. Eng.*, Introduction to Ind. & Mgmt. Sys. Eng.*, Basic Information Processing Workshop*, Introduction to Mgmt. Design, Mgmt. Practicum in Japan, Mgmt. Practicum Abroad, Ind. & Mgmt. Sys. Eng. Study Abroad Program
2nd year	*Introduction to Probability*, Fundamental Information Science*, Introduction to Operations Research*, Operations Research Workshop**, Information Processing Sys. Workshop*, Method Eng. Workshop*, Computer Technology*, Operations and Production Mgmt., Experiments of Manufacturing Sys. Engineering*, Quality Mgmt., Fundamentals of Sys.*, Profit Mgmt.*, Fundamental of Manufacturing Eng.*, Ergonomics*, Mgmt. Planning
3rd year	Ind. and Mgmt. Eng. Seminar A*, *Multivariate Analysis A and B, Design of Experiments, Mathematical Statistics, Knowledge Information Processing, Marketing Research, Data Applied Information Sciences, Eng. and Exercise, Operations Research A and B, Optimization and Simulation Exercise*, Human Life Eng., Facility / Logistics Design, Corporate Finance, Production and Supply Chain Mgmt., Facility Mgmt., Eng. Mgmt., Logistics, Ind. and Mgmt. Sys. Eng. Seminar, Human Factors Mgmt., Human Resource Development, Applied Systems Thinking, Cooperate and Marketing Strategy, Manufacturing Process Technologies, Manufacturing Systems, Software Eng., Information Systems, Introduction to Environmental Mgmt., Energy Mgmt., Introduction to Mathematical Eng.
4th year	Ind. and Mgmt. Eng. Seminar B*, Mgmt. Sys. Eng.: Practical Exercise*, Research Seminar*, Graduation Thesis*, Enterprise Strategy, Software Mgmt., Mgmt. of Research and Development A and B, International Intellectual Property Rights Business Theory A and B

(Legend – *: compulsory subject; Ind.: Industrial;
Mgmt.: Management; Sys.: Systems; Eng.: Engineering)

There are 14 faculty members in our department. The field of research is roughly divided into production system, information system, and mathematical science. More specifically, it includes production and distribution systems, production management, maintenance engineering, logistics, quality management, cost management, ergonomics, systems theory, software engineering, artificial intelligence, information statistics, statistical science, optimization theory, and operations research.

Part-time lecturers also supplement the usual coursework with special subjects from a broad perspective. In addition, we let our students learn fundamental subjects such as linguistics,

general liberal arts subjects, mathematics, and physics. Furthermore, it is one of the features of our department that we require economics as a compulsory subject.

The specialized education subjects of our department are shown in Table 1. In this table, statistics or strongly related subjects are shown in bold and underlined. Also, mathematical science subjects closely related to statistics are italicized and underlined. However, in other subjects, there are many scenarios that involve applying statistical methods. The lecture subjects consist of 15 lectures of 90 minutes each. Some instances of exercise subjects are conducted in 90-minute and 180-minute formats, but both are conducted 15 times.

In recent years, the need for data scientists has risen. It is said that three skills are required for the data scientist: business skills, IT skills, and statistical analysis skills. Business skills are considered to consist of practical experience and management knowledge. Although it is difficult to educate students in business skills in depth at university, Table 1 shows that our department is aiming to teach useful practical knowledge in various workplaces. Next, with regard to IT skills, our department provides several information-related subjects, and we are using programming, general purpose algorithms, and specialized software. Regarding statistical analysis skills, we provide a variety of subjects and workshops, and we are developing a satisfactory educational environment for learning statistics. Therefore, if students take elective subjects properly and then graduate research in a laboratory specializing in statistics, they will have mastered the three skills necessary for a data scientist to a high level. However, if students avoid elective subjects related to statistics, such levels cannot be reached.

In our department, approximately half of about 130 undergraduate graduates go on to graduate school and an MSc. On the other hand, there are very few students who go on to doctoral studies each year.

Fifty percent of graduates' employment is in the manufacturing industry, 20% in the information industry, 10% in the financial industry, 10% in logistics and services, and 10% in others. In the manufacturing industry, students have a chance to make use of the education acquired in our department at work such as planning, design, development, and quality assurance. In the information industry, they sometimes work with knowledge of statistics and operations research. In the financial industry, there are people who achieve actuary qualifications. Some students pass the certified accountant exam, at a rate of about one student every two years. In the second specialized examination for certified public accountants, there are statistics kept on the examination subject.

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Table 2 shows the subjects strongly related to statistics among the subjects listed in Table 1. Of the subjects listed in Table 2, the subjects of the first and second year are compulsory, and the others are electives. Approximately 80% of the students in the department take Multivariate Analysis method A, and about 30–60% of students take other subjects. If students take all of the subjects in Table 2, almost all statistical sciences will be covered.

Students who take many of the subjects listed in Table 2, and have been assigned to the statistics laboratory or related labs and have taken graduation-level research can obtain sufficient knowledge of statistical science. In addition to the subjects in Table 2, students will take subjects and workshops such as business skills and IT skills, so it is possible to create competency as a data scientist.

As all students belonging to Department of Industrial and Management Systems Engineering of Waseda University cannot undergo the above-mentioned process in completing courses, it is not appropriate to call our department "Department of Data Science." However, we are proud that our department is able to produce students with such abilities, although they are partial. Moreover, our department's students find employment in various industries when compared to other departments of science and engineering. This means that they are building a business network naturally, in their school days.

CONCLUSIONS

It has been said that no departments of statistics exist in Japan. However, it may be that there are not many people who know of the existence of Department of Industrial and Management Systems Engineering and its educational content. In Japan, there are few universities where

Table 2. The subjects strongly related to statistics

Gr	subjects	contents
1st	*Statistical Analysis*, Statistical Analysis Workshop**	How to summarize data and calculate statistics, probability distribution, test and estimation, one sample problems, two sample problems, goodness of fit test, test of contingency tables, one-way layout experiment, two-way layout experiments, correlation analysis, single regression analysis
2nd	*Introduction to Probability**	Definition of probability. random variables, probability distribution, conditional probability, Bayes' theorem, expectations, sample surveys, application of probability, Monte Carlo simulation
2nd	*Fundamental Information Science**	Binary operations, sets and logic, statistical decision theory, information theory, machine learning, pattern recognition
3rd	*Multivariate Analysis A and B*	Regression analysis, path analysis, discrimination analysis, principle component analysis, quantification theory, decision tree, cluster analysis, graphical modeling, logistic regression analysis, Multivariate Analysis B: Practice exercises using PC software
3rd	*Design of Experiments*	One-way layout experiment, two-way layout experiment, multi-layout experiment, orthogonal array experiments, randomized block design, split-plot design, planning and proceeding with the experiment
3rd	*Mathematical Statistics*	Probability distribution, expectation, variance, joint distribution, marginal distribution, transformation, conditional distribution, basic theorem, estimation theory, test theory, decision theory
3rd	*Knowledge Information Processing*	Artificial intelligence, networks, natural language processing, image processing, machine learning, neural network, evolutionary computation
3rd	*Marketing Research*	Market research, marketing data analysis, consumer behavior model, marketing models, information technology, business analytics
3rd	*Data Applied Information Sciences*	Pattern recognition, statistical decisions, discriminant analysis, template matching, k-NN method, neural networking, decision trees, ensemble method, random forest
3rd	*Data Eng. and Exercise*	Programming, network, data compression, error correction, text mining, data mining

departments of industrial and management systems engineering are established. Moreover, given the absolute number of data scientists required, the number that our department is producing may be small. However, students who have taken the proper statistics-related subjects in our department are able to acquire a well-balanced business sense through synergies, such as taking subjects related to other management techniques and building friendships in the same department; they have the potential to become the ideal data scientists.