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A STUDY ON TEACHING METHODS OF MATHEMATICS SUBJECT IN THE FACULTY OF ECONOMICS

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Abstract. *In Japan, recently, reduction in the mathematical ability of the students has been pointed out. Mathematical ability has shown to influence the future income. Therefore, the efficient learning method in a university is needed for the students who did not learn fundamental mathematics at a high school. The purpose of this paper is to clarify that it is a necessity of the knowledge of the fundamental mathematics for the understanding of the lecture of the faculty of economics. Concretely, we use the one-way analysis of the grade of economic mathematics and total score. As a result, we clarify the relation between the mathematics knowledge and the economics subject. In addition, we propose the following means to improve the quality of education. In order to realize it, teachers will assist the learning in the time outside the lecture or to create an auxiliary document for Fail and Pass students. In addition, it is needed for the student who is not good at math performing the motivation for selecting the mathematics subjects.*
Keywords: One-way analysis of variance, Mathematics knowledge, Quality of education

1. **Introduction.** After the government guidelines for teaching of the 1989 notification, it is said that the contents of the mathematics which we learn at a high school decreased 30 percent [1]. There are actually many students who are not learning some mathematical subjects in the department of economics of Kobe Gakuin University [8, 9, 10].

However, Urasaka et al. [3] have reported that math learning gives a positive impact on the income of students who have graduated from a private university liberal arts faculty. Mathematics is one of the subjects that students must learn for their future.

The decrease in the math ability of college students has been pointed out. Mathematical knowledge is indispensable in order to understand economics. However, the students who do not know it are increasing yearly. Nakamura [4, 5] has studied about the relation between mathematical capability and the understanding of economics from the results of one certain subject.

It is difficult for a student to understand the same contents of learning in the present lecture style under such a situation. In this paper, we aim at clarifying relationship of the economic mathematics achievement and a student's total score. Here, economic mathematics is one of the subjects for supporting fundamental math ability. The total score

is the number of overall points of the subject's evaluation which the student mastered. Furthermore, we discuss about the learning method which raises the educational quality.

Here, the purpose of this study is to propose the efficient teaching methods to teachers in charge of basic mathematics, and to build a support system for students to learn voluntarily mathematics subjects. Therefore, we need to discover the knowledge from a large amount of performance data held by the university, and help it to improve the future of education.

2. **One-way Analysis of Variance.** One-way analysis of variance experiments on a certain factor to two or more levels in the completely random order to analyze the factor of the characteristic. Table 1 shows the data organization used by the one-way analysis [11].

TABLE 1. Data organization

Level	Data	Sum	Average
A_1		T_{A_1}	$\bar{A}_1$
$\vdots$		$\vdots$	$\vdots$
A_i	x_{ij}	T_{A_i}	$\bar{A}_i$
$\vdots$		$\vdots$	$\vdots$
A_a		T_{A_a}	$\bar{A}_a$
		$T = \sum T_{A_i}$	$\bar{T} = \sum \bar{A}_i$

The jth data x_{ij} with ith treatment group is formulated by

$$x_{ij} = \mu_i + e_{ij} \tag{1}$$

where, μ_i is the mean of the observations for the ith treatment group, and e_{ij} is normally distributed zero-mean random error. Here, the sum of square of the one-way analysis can be divided as follows

$$S_T = S_e + S_A = \sum \sum \left(x_{ij} - \bar{A}_i\right)^2 + n \sum \left(\bar{A}_i - \bar{T}\right)^2 \tag{2}$$

Table 2 is an analysis of variance table. Here, a is the number of levels, and n is the number of experimental units.

TABLE 2. Analysis of variance table

	Sum of squares	Degrees of freedom	Mean square	F
Treatments	S_A	$f_A = a - 1$	$V_A = S_A/f_A$	V_A/V_e
Error	S_e	$f_e = a(n-1)$	$V_e = S_e/f_e$	$-$
Total	S_T	$f_T = an - 1$	$-$	$-$

3. **Numerical Experiment and Analysis.** The purpose of this study is to clarify that it is a necessity of the knowledge of the fundamental mathematics for the understanding of economics. Therefore, x_{ij} is given as the total score of student j whose evaluation of economic mathematics I and II is A_i.

$$x_{ij} = 4 \cdot a_j^S + 3 \cdot a_j^A + 2 \cdot a_j^B + 1 \cdot a_j^C \tag{3}$$

where, a_j^* is the number of $*$ evaluations that student j has acquired so far (S: Excellent, A: Good, B: Fair, C: Pass). Table 3 shows the sample of the data used to experiment (data of the first year in economic mathematics I).

Table 3. Sample data of the first year in economic mathematics I

Excellent	24	31	45	35	38	25	46	···
Good	25	32	26	32	23	43	27	···
Fair	31	40	30	35	40	29	21	···
Pass	6	24	18	14	31	14	25	···
Fail	6	7	13	11	21	17	26	···
Non-choose	12	9	5	4	4	11	1	···

Moreover, Table 4 is the breakdown of the evaluation of learning results of economic mathematics I and Ⅱ. Here, ⌈I⌋ and ⌈Ⅱ⌋ mean economic mathematics I and Ⅱ, respectively. Moreover, the data of economic mathematics Ⅱ of the first year is lacked. The evaluation of learning results of the 3rd year and the 4th year does not have Excellent.

Table 4. The breakdown of the economic mathematics I and Ⅱ

		Excellent	Good	Fair	Pass	Fail	Non-choose
1st Year	I	5.9%	6.2%	12.9%	12.1%	18.6%	44.3%
	Ⅱ	—	—	—	—	—	—
2nd Year	I	3.7%	8.9%	10.6%	24.1%	25.6%	27.1%
	Ⅱ	1.7%	0.7%	4.2%	9.9%	8.1%	75.4%
3rd Year	I	—	7.0%	14.9%	20.5%	18.4%	39.2%
	Ⅱ	—	4.1%	4.1%	12.3%	8.2%	71.3%
4th Year	I	—	9.9%	9.4%	13.8%	20.6%	46.4%
	Ⅱ	—	6.5%	6.5%	7.0%	15.4%	64.6%

The ratio of Non-choose in mathematics Ⅱ is higher than mathematics I. This shows that the student who selects economic mathematics Ⅱ is fewer than economic mathematics I. This reason is that the content of economic mathematics Ⅱ is difficult. A student not good at mathematics tends to avoid selecting it. It is paid attention to that the ratio of Fail in economic mathematics I is comparatively high. This lecture includes a lot of content of high school mathematics. Therefore, it is considered that it is because there are a lot of students who take the test without studying.

Next, the analysis of variance table obtained by one-way analysis of variance is shown in Table 5.

Table 5. The analysis of variance table

			Sums of squares	Degrees of freedom	Mean Square	F value	P value	
1st Year	I	Treatments	9469.2	5	1893.84	27.97	2.74E−24	**
		Error	26951.1	398	67.72			
	Ⅱ	—	—	—	—	—	—	
2nd Year	I	Treatments	58152.3	5	11630.46	25.55	2.221E−22	**
		Error	182100.8	400	455.25			
	Ⅱ	Treatments	23450.1	5	4690.02	8.65	8.415E−08	**
		Error	216803.0	400	542.01			
3rd Year	I	Treatments	20681.9	4	5170.48	7.33	1.141E−05	**
		Error	237769.7	337	705.55			
	Ⅱ	Treatments	7340.3	4	1835.06	2.46	0.0450736	*
		Error	251111.3	337	745.14			
4th Year	I	Treatments	35806.2	4	8951.56	13.94	1.274E−10	**
		Error	243334.0	379	642.04			
	Ⅱ	Treatments	24230.6	4	6057.64	9.01	5.87E−07	**
		Error	254909.6	379	672.58			

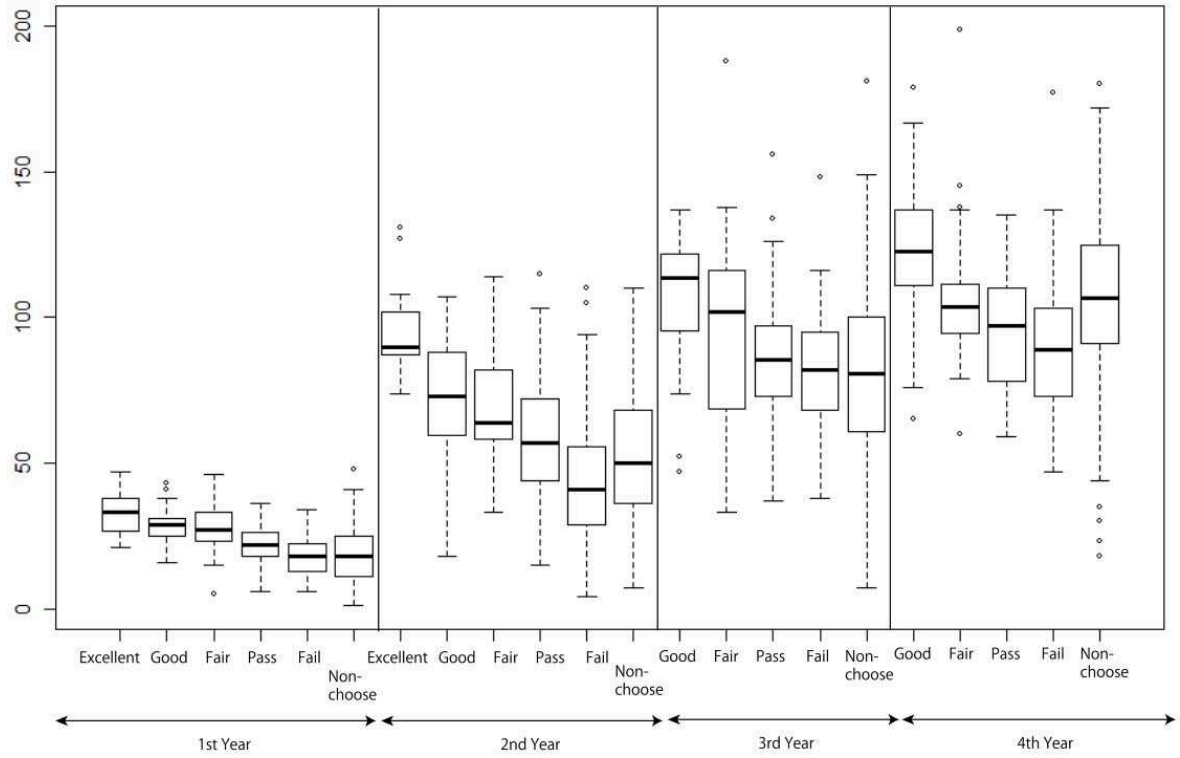

FIGURE 1. The boxplot in economics mathematics I

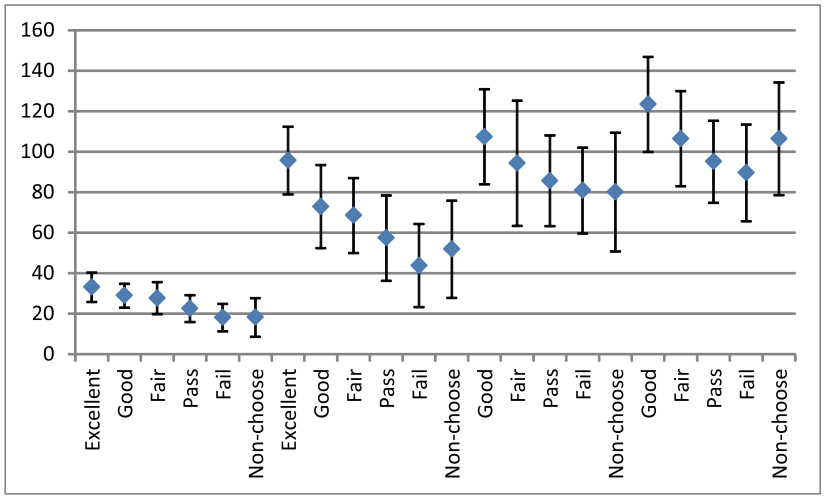

FIGURE 2. The plots of the mean value in economics mathematics I

From Table 5, it is shown that the results in all years achieve statistical significance. In a word, the evaluation of learning results of economic mathematics is related to the total score. In addition, the boxplot of data concerning economic mathematics I and II is shown in Figure 1 and Figure 3, respectively. Figure 2 and Figure 4 are plots of the mean value. In these figures, a year rises to the right from the left. And, the evaluation of learning results rises to the right from the left. Note that, the vertical axis shows the total score.

From these figures, the mean value of the total score of the student who acquires Excellent or Good is higher than that of the student of Non-choose in any year. In a word, the student who understands mathematics gets a good score. The understanding of mathematics is indispensable for the study of economics. Therefore, it is thought that the student with a good grade of economic mathematics understands other classes easily.

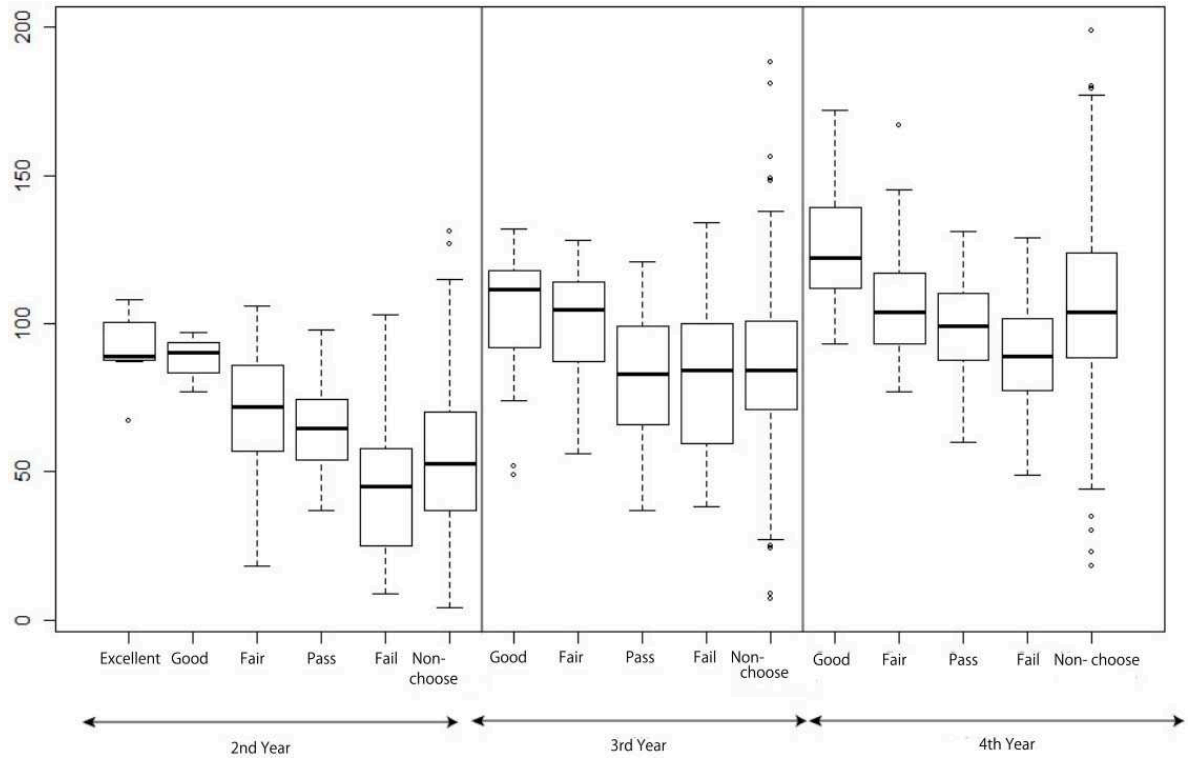

FIGURE 3. The boxplot in economics mathematics Ⅱ

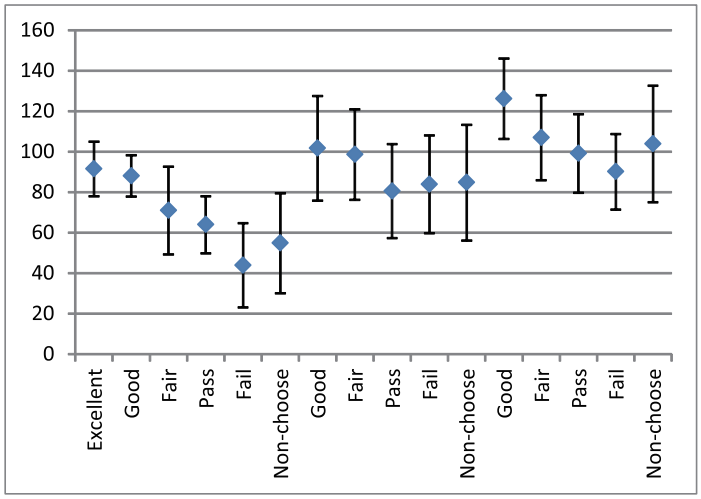

FIGURE 4. The plots of the mean value in economics mathematics Ⅱ

Oppositely, the total score of the student who is the evaluation of Fail is low. It is thought that the student of Non-choose has already studied in the high school or is not good at mathematics. Therefore, decentralization is large.

Finally, we focus on the fourth year, and show the percentage of the performance evaluation of the students who attended only economic mathematics I or Ⅱ in Table 6. In other words, in the evaluation of economic mathematics I being Good, and the percentage of the students who did not attend the economy mathematics Ⅱ is 18%.

From Table 6, 77% of student who was Fail in economic mathematics I, did not attend economy mathematics Ⅱ. Fail students were considered to be more difficult to pass the difficult economic mathematics Ⅱ than economic mathematics I. Therefore, A student not good at mathematics tends to avoid economic mathematics Ⅱ.

TABLE 6. The rate of the only economic mathematics I and II

	Good	Fair	Pass	Fail
Only Economic Mathematics I	18%	42%	47%	77%
Only Economic Mathematics II	16%	4%	26%	44%

To improve the quality of education, we propose the following methods of two points from these results.

1. Execution of supplementary learning method to shift student of Fail to Pass
2. Proposal of program that the student who does not like mathematics (Non-choose) chooses a mathematics subject

1: When most of the students of Fail are of a high school, mathematics is not studied. Such a student should spend time studying. That is, the teacher should propose to study by the lecture overtime.
2: A student not good at mathematics tends to avoid the subject of mathematics. However, the knowledge of mathematics is needed in the specialized subject and the employment examination. An environment making that the student notices the necessity early is requested.

4. **Conclusion.** The decrease in the math ability of students has been pointed out. We analyzed the impact of the performance of mathematic subjects on the university results. In this paper, we used the one-way analysis of the grade of economic mathematics and total score. As a result, we clarified the relation between the mathematics knowledge and the economics subject. In addition, we proposed the means to improve the quality of education. It is possible for teacher to carry out the motivation for students to study mathematics at an early stage. However, it is difficult of the after-class hour learning assistance. Therefore, we think that it should be considered of some measures in all teachers of the faculty of economics. In the future work, we will immediately compared with other subjects. The ability of language and information, statistics is indispensable in order to understand the economics. After we compared with them, we are planning to build a support system that provides an efficient teaching method. In addition, we believe we help to rethink the curriculum of the faculty of economics.

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