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PROPOSAL OF TASK CREATION SUPPORT SYSTEM USING CLUSTER ANALYSIS BASED ON LEARNING DATA

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Abstract. *In recent years, the qualitative change of university education is desired in Japan. Therefore, it is necessary for the university teacher to review an education method. In this paper, we propose the task creation supporting system for a student's improvement in motivation. Using learning data, it is possible to create tasks that match student's learning situations. Furthermore, giving students differing degrees of difficulty leads to motivation of students.*

Keywords: Class improvement, One-way analysis of variance, Cluster analysis

1. **Introduction.** Since the Central Council for Education reply in August, 2012 was released [1] in Japan, the quality of university education has been asked. In order that the quality of the education is recognized by society, the university should try hard. And, the teacher needs to continue groping for the learning method for gaining minimum standards for graduation.

Currently, most universities in Japan are improving classes through questionnaire evaluation questionnaire by students. However, contents with a high implementation rate are holding lectures [2]. From now on, it is thought that faculty members need to understand educational opportunities and so on according to individual learning level [3].

The American Psychological Association Task Force advocated the view of "learner-centered" [4]. This is a viewpoint which focuses on an individual student and also perceives learning itself simultaneously. Those who are educated, such as a teacher, are asked for it. Ames has shown that it is important to offer the learning task of the degree of difficulty optimal for a student [5]. Based on grasping the learning suitability of each individual, it is a task to individually adjust the type and difficulty of the assignment [6].

We focus on the lecture about the fundamental mathematics which one of authors teaches, and have researched aiming at a class improvement [7-10]. In order to improve the lesson as a student-based entity, we conducted questionnaires to students and pursued satisfying classes. In this paper, we propose designing support system for task creation for motivation of students. Here, the task usually refers to paper, but because the target class is fundamental mathematics, it means calculation problem. However, there are many cases where students' desired level is not appropriate. Therefore, by conducting cluster analysis using student's understanding data, students are divided into several clusters.

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Then, we propose that students choose the appropriate level of tasks according to the learning direction.

2. **Relationship between the Difficulty Level of Task and the Examination Score.** First, we carried out the midterm exam to 101 students who are taking the object lecture, and carried out the following questionnaire to them simultaneously. "When there are the following three levels tasks in the future, which task do you choose?" A student has chosen from "(A) easier level, (B) normal level and (C) more difficult level". Here, "(B) normal level" indicates the level of the learning task carried out until now. Concretely, the normal level is set up a little more highly than the level of the text. To examine the relation between the task level and the score, we apply one-way analysis of variance.

One-way analysis of variance experiments on a certain factor to two or more levels is 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]. Concretely, in order to analyze the factors of the characteristics, only one factor A is taken up. Then, we choose the level $a(A_1, A_2, \ldots, A_a)$ for that factor and do experiments in completely random order.

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 the 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 shows an analysis of variance table and the result. 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	Variance	F
Treatments	$S_A = 1121.732$	$f_A = a - 1 = 2$	$V_A = S_A/f_A = 560.8658$	$V_A/V_e = 6.662494^{**}$
Error	$S_e = 8165.708$	$f_e = a(n-1) = 97$	$V_e = S_e/f_e = 84.18256$	–
Total	$S_T = 9287.44$	$f_T = an - 1 = 99$	–	–

Compared with the value of $F_{f_e}^{f_A}(0.05) = 3.09$ and $F_{f_e}^{f_A}(0.01) = 4.83$, F value exceeds both the values. And, P value = 0.001944 is significant in the level of 1%. That is, it can be said that there is a difference on the average of the score of the examination by the task level that the student selected.

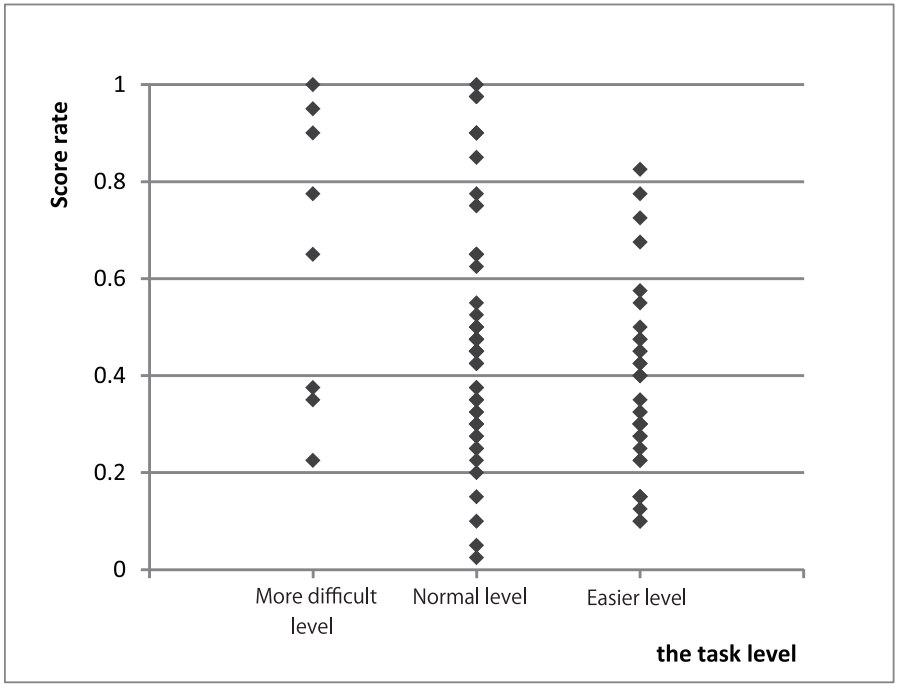

FIGURE 1. Plot of scoring rate at each difficulty level

It is thought from this result that experimental score might determine the level of a learning task. The relation of the degree of difficulty and a score of a midterm exam is shown in Figure 1.

There are a few students who chose the more difficult tasks from the figure. However, not only the high student of score but the low student of score exists. It proves that some students with low score have high motivation. Because the student who selects "normal level" exists in the range of almost all scores, it can be said that the level of a present task is appropriate. The student of the score rate of 90 percent or more does not exist in "easier level". This level contains a lot of students of the score rate of 20-50 percent. These students want to strengthen the basis by the simple question and to improve the level.

The intrinsic motivation in an object subject is that mathematics is the knowledge which is needed when obtaining specialized education in the future. Moreover, the greatest intrinsic motivation is useful for a future examination for employment.

3. **Mechanism for Task Creation Based on Student's Understanding Data.** It is necessary to select the task level for which the student individual hopes to improve student's motivation. However, it is not easy to know the student's examination score before the task is given. In this paper, we propose the method of designing the task making support system to improve student's motivation. The data whether the student understood the task of the lecture is collected. And, we propose to decide the level of the task by using the cluster analysis.

Here, we use the data of 69 students who attended the lecture on a certain day. ◯ shows that the task was able to be solved and × shows that the task was not able to be solved about five tasks from (1) to (5). Table 3 shows the task number.

The example problem is a problem that the student solves by himself after the teacher explains how to solve. And, "practice question" is a review and an unseen passage to "example problem" ahead of that. For instance, the data of a certain student who answered as shown in Table 4 is set according to the entire correction rate shown in Table 5 as Table 6.

TABLE 3. Task number

Task No.	Contents
(1)	Example problem 3.4
(2)	Practice question 3.4
(3)	Example problem 3.5
(4)	Practice question 3.5-1
(5)	Practice question 3.5-2

TABLE 4. Understanding status of one student

(1)	(2)	(3)	(4)	(5)
○	×	○	×	×

TABLE 5. The rate of correction as a whole

	(1)	(2)	(3)	(4)	(5)
○	0.25	0.30	0.43	0.22	0.14
×	0.75	0.70	0.57	0.78	0.86

TABLE 6. Input data of one student

(1)	(2)	(3)	(4)	(5)
0.25	0.70	0.43	0.78	0.86

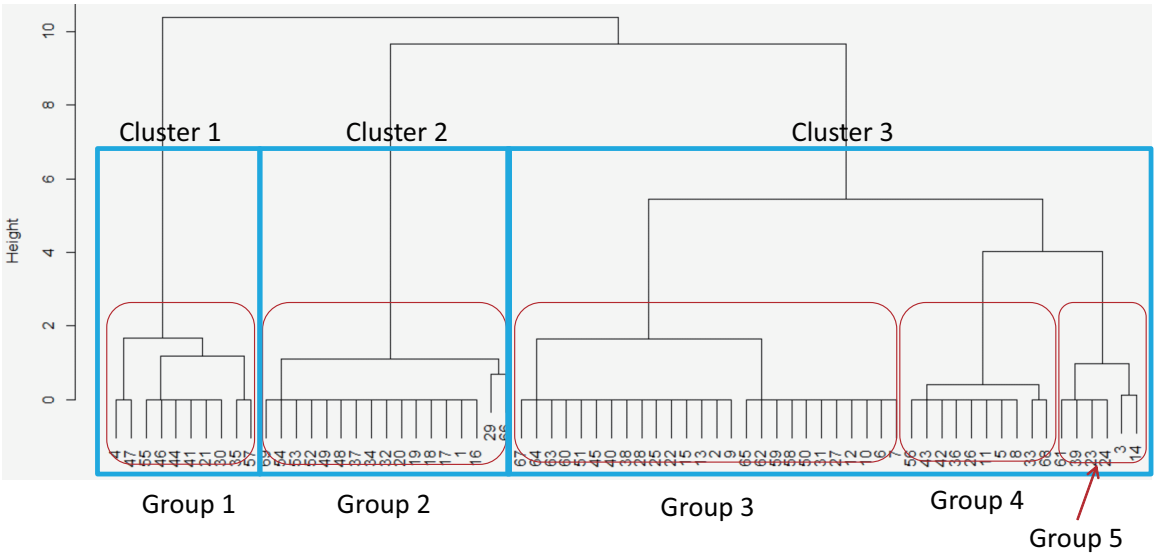

FIGURE 2. The result of cluster analysis

The difference between the student who was able to solve the problem and the student who was not able to solve it is appropriately reflected by assuming this to be input data. Figure 2 shows the result of clustering by using this input data. Here, the Ward method was used. This method forms clusters so that the sum of squares in the cluster is minimized. It has good classification sensitivity and is the most commonly used, so we also use it.

In this paper, because the problem level is set as three stages, Figure 2 is divided into three clusters. And, each cluster is divided into the subgroup that shows in Figure 2. Here, the number of subgroups is five. The relation between the number of students and

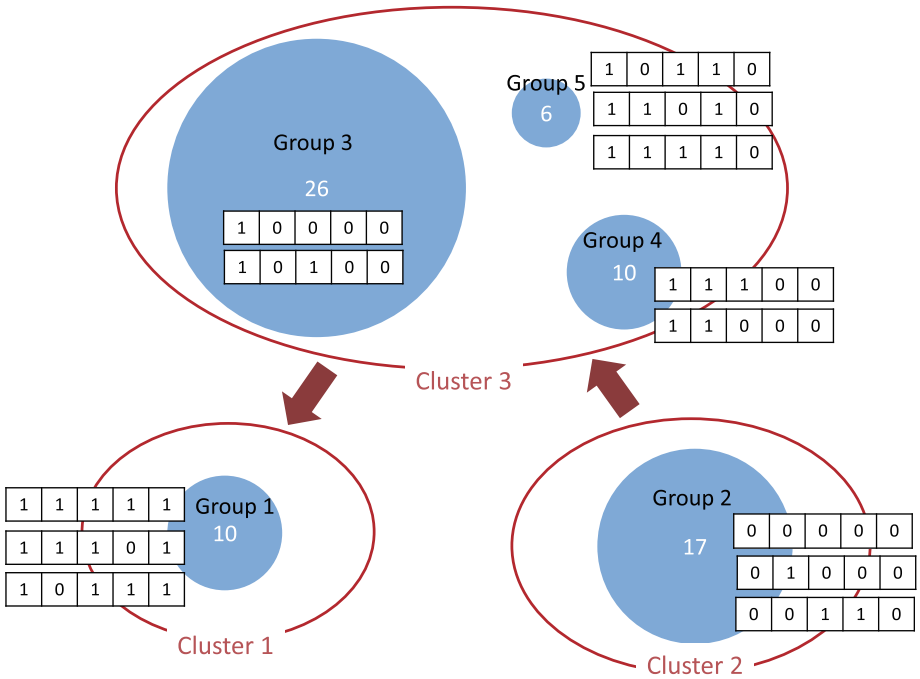

FIGURE 3. Example of learning network

the cluster of each group is occupied to Figure 3. Here, because the size of circle of the group depends on the number of students that belong to the group, circle of group 3 is the largest. And, the data that is next to the group shows which problem was able to be solved by the student who belongs to the group. Concretely, | 1 | 0 | 1 | 0 | 0 | mean that the student can solve (1) and (3), and cannot solve other problems.

It is understood that the accuracy rate of cluster 1 is higher than the student of other clusters. Similarly, it is understood that the accuracy rate of cluster 2 is lower than that of the student who belongs to other clusters. Then, we propose that the cluster 1 selects more difficult level, the cluster 2 selects normal level and the cluster 3 selects easier level. Thus, it is not a teacher subject but a student subject to use the cluster analysis and to decide the difficulty degree of the problem. Therefore, this method is more effective than the case decided by the score of the examination.

4. **Conclusion.** In this paper, we proposed the task creation supporting system for a student's improvement in motivation. We proved the relationship of the average of a score of a midterm exam and the task level by one-way analysis of variance. And we proposed selection of the adequate task level from the data of whether to solve the exercise and the exercise using cluster analysis. In the future, we will clarify the network between groups. And we are going to implement a proposal system by a Web system.

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