An Effective Class Organization Support System based on Multi-attribute Utility Theory

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Summary
This paper focuses on the importance that class-formation of optional subjects in school education can affect learners. And it will point out problems about conventionally 'mechanical' class-formation, and suggest a method of class-formation based on multi attribute utility theory, which is taken into consideration students' preferences. Therefore, this paper exercises experiments by a new method and a conventional one, and demonstrates its priority. This also constitutes a prototype-system.

Key words:
Elective subjects, Decision making, Multi-attribute utility theory

1. Introduction

In recent years, the importance of elective subjects is increasing at schools. Moreover, the role and function of elective subjects also attract attention very much. Since students can choose a subject based on their interest and own concern, elective subjects is very useful in the present education at schools in recent years.
Elective subjects pulls out students' opinions and concerns. Elective subjects are the most important communication tools for making students' concern reflect in schools. We consider it the biggest subject of school education in the future to use an elective subjects effectively at schools. However, the technique of class organization of the conventional elective subjects is based on “the order of arrival, the order of a grade, or the selection at random”. Current class organization of the conventional elective subjects is based on scarce restrictions of a basis. By such a former type technique, a student's concern is not fully reflected effectively. Therefore, current elective subjects’ cannot be evaluated highly. It cannot be said to be fully able to reflect the function of an elective subjects. In this paper, we paid our attention to the importance of class organization of the special elective subjects in a university. And we point out the problem of the conventional organization technique and propose concerned with the class organization technique that can reflect a student's preference.

Generally, it is said that person's decision-making is based on a Multi-attribute preferences (concern) [6][7]. Therefore, the purpose of this paper is building the system based on his/her realistic decision-making. We propose the support system using the class organization technique based on multi-attribute utility theory.

In class organization of an elective subjects, two or more restrictions, such as a seating capacity of a classroom and prohibition of duplication completion in the same period, can be considered in addition to a request of a student. We propose the class organization technique considered above restrictions.

The rest of the paper is organized as follows. Section 2 describes the outline of our user support system. In Section 3, we give some definitions and assumptions for the system. We show how classes are formed and organized using our system. In Section 4, we show user interface examples of our system. Finally in Section 5, we provide some final remarks.

2. Elective Subjects and Class Organization

In this section, it outlines the class organization in an elective subjects, and the purpose of this paper is explained in full details. And the problem of the conventional class organization method is pointed out.

2.1 The kind of elective subjects

In a university, "the usual elective subjects" and "laboratory selection for graduation research" exist in an "elective subjects." Furthermore, "the elective subjects in liberal arts" and "the elective subjects in a special subject" exist in the former. This paper is aimed at the "elective subjects in a special subject" that will affect most of participants' essential purpose and essential concerns, and study volitions. Fig1 expresses positioning about the elective subjects treated in this paper.

Graduation research and laboratory selection are fundamentally based on subjectivity and preference of each teacher. Moreover, it is also possible to make a student's intention and a request reflect. Moreover, in

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many cases, there is a consultation in advance between a teacher and a student. Consequently, an interactive relation exists between a teacher and a student. Namely, users preferences are not reflected by current class organization methods. However, compared with laboratory selection, the following problems remain in the so-called "special elective subjects."

(1) A similar choice does not exist in others in many cases.
(2) Since there is much number, consultation between a teacher and a student is difficult.
(3) As a result, sorting is mechanical.

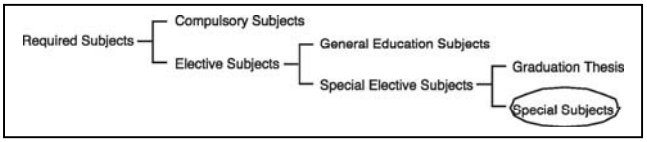

Figure 1: the elective subjects treated in this paper

2.2 Importance of an elective subjects

An elective subjects acts on a student's study volition and motivation intensively. The factors as which a student chooses a subject are own interest and concern. It also serves as an element that makes a student's motivation and study volition amplification. On the other hand, when it cannot fulfill (namely, when a lecture on the subject for which a student wishes is not able to be taken), a lecture on other subjects must be taken, or attendance must be stopped, and attendance hope must be again carried out to the next term. For example, considering the case where the candidate more than the number of seating capacity of a lecture room exists in Lecture A, the student of more parts than the number of seating capacity cannot do completion.

In a preliminary survey, even if he/she can wish two or more lectures, many students have to take in fact a lecture on the subject for which he/she does not wish by class organization based on single standards (the order of a grade etc.). The propriety of attendance of the subject in which he/she desired has a big influence on a student's study volition.

2.3 The factor of subject selection

It is thought that a judgment standard in case a student chooses a subject has more than one. The standard about interest and concern was mainly shown in the higher rank as a result of the questionnaire. Table1 is the results of an investigation about the selection standard in the case of wishing an elective subjects.

First, the standard considered by the student was investigated by the questionnaire. (1) The attribute considered in the lecture selection by the elective subjects was made be mentioned to all subjects, and the attribute considered to be the same was summarized. The attributes considered being the same are "qualification", "license", etc. Next, three items of higher rank of the attribute considered to be important as a standard at the time of each subject choosing a subject was made to choose for the same subject about the attribute summarized by (1). Consequently, the necessity for (1) interest and concern, (2) ease, and (3) qualification authorization, (4) human relationship, and five factors of (5) time, were shown fundamentally.

First, the first factor is "interest and concern." That is, this is a positive factor. Next, the second factor is a negative factor whether acquisition of the unit for graduating is easy. And as the third factor, in order to acquire qualification, it is the factor that it is necessary to choose a certain specific subject among elective subjects. In this case, even if it is an elective subjects, it is thought that it is the same as a required subject. Next, the fourth factor is human relations. That is, it is a factor of a teacher's selection. And the fifth factor has a time factor. That is, it is a student's schedule-problem. It can be said that the key factor for a student choosing a subject is the five above-mentioned factors. Furthermore, a selection person's cooperative-relations factor acts (the same subject is chosen by friends). However, fundamentally, these five factors serve as a base and a student chooses a subject. Of course, although there is a difference in these 5 factors according to the level and custom of each school, it is essentially thought that it is changeless of the role of these five elements. These 5 factor serves as a base and students' preferences expresses as a selection act of a subject.

Table 1: the results of an investigation.

Standard	Number
Interest	11
Difficulty	9
Time	7
Human Relations	6
For Qualification	3

2.4 The problem of subject selection

When employing an elective subjects, it is the biggest problem that it is "selection." Since an elective subjects is an "elective subjects", if attendance candidates increase in number, based on restrictions and mechanical fairness without bases, such as a lottery, the order of a grade, and the order of arrival, a school has to select an attendance student.

Therefore, an attendance candidate cannot necessarily take a lecture on the subject in which he/she desired. That is, as a system, although an elective subjects is selection therefore, it has the paradox that a user's (= attendance candidate) preference cannot be satisfied.
The elective subjects exist in order to take into consideration a student's preference (interest, concern, and aptitude). And in spite of employing the elective subjects for the purpose of enlarging a student's utilities (= satisfaction), as a matter of fact it has the fatal defect in that user's preference cannot be satisfied. And the dissatisfaction of a student's utilities in an elective subjects hurts students' study volition and motivation greatly. The elective subjects also have very serious educational problem. For example, a student with the motivation against study of the subject is defeated only in the measure of a lottery. However, there is a fact that another enervated student submits an attendance report by chance, and is selected by the lottery, well. The fact is more dangerous than anything. The student with strong study volition will take a lecture on the subject for which others do not wish "in order to graduate." The student who has taken a lecture of the subject in which he/she desires is also disappointed at the classroom which was full of a complaint and enervation.

3. The Proposal of the Class Organization Method and Validity

This section shows the outline of the class organization method based on multi-attribute utility theory proposed in this paper. And a simulation experiment shows the validity of this research.

3.1 The outline of restrictions and a method

We took into consideration that this class organization method was an actually employed general-purpose in a university. Consequently, we thought that a system with few burdens of an input of a user was indispensable. Then, a student's input prepared restrictions of two points so that it might decrease as much as possible. It is thought that these two restrictions can be used in the investigation of choice of an actual elective subject. The first point is physical restrictions and the second point is institutional restrictions. The former is the restrictions about the width of a lecture room, that is, the restrictions about a seating capacity. The latter can be classified into the following (1) and (2). (1) Prohibition of the completion that overlapped at this time. (2) Prohibition of completion of the subject that already acquired the unit.
In this system, the determination of subject completion is supported by multi-attribute utility theory [2]. A utility is defined as the "joy" at the time of gaining a certain goods in economics [3][4]. Generally, It is discussed by multi-attribute utility theory, when a certain selection problem exists and the choice characterizes according to two or more attributes. In many cases, Human's decision-making is determined based on a multi-attribute preference [5]. Therefore, it seems appropriate to introduce multi-attribute utility theory into determination support of subject completion of a student. In a case a student chooses one of two or more lectures, he/she chooses based on two or more attributes, such as interest, ease, etc. to a lecture. Therefore, a student's subject selection is applied to a multi-attribute utility theory, and can formulize a problem. For example, a certain selection problem exists and supposes that there are X and Y as an attribute. When the value about each attribute is set to x and y, the following formula can define a multi-attribute utility function.

$$U(x\_ y) = F(f\_x(x), f\_y(y))$$

Here, f_x and f_y are the utility functions in the attribute value x (and y) of the attribute X (and Y) of a certain lecture, and F is a function for synthesizing the utility function in each attribute. U (x y) is a utility synthesizing the multi-attribute use in a certain lecture. In this system, in case a student chooses two or more lectures, it chooses based on two or more attributes, such as "interest to a lecture, concern, ease, and human relations." Therefore, it applies to multi-attribute utility theory, and a problem can be formulized. Class organization of the elective subject based on multi-attribute utility theory overcomes the serious paradox in assignment of the lecture based on the existing ranking of choice, i.e., the problem of "determining mechanically, without taking a student's utility into consideration in spite of the system for taking a student's utility into consideration."

3.2 Vote by students

A student inputs for every lecture about multi-attribute shown by 2-3. In the prototype system shown in this paper, a user can do authorization vote for the subject expected of an elective subject to three. Although it is three here, it is possible to change according to the width of a lecture room and the scale of a university. Especially, a student's hope can be made to reflect more by increasing the number which can be inputted, when there are many subjects. A student checks about each attribute and each subject for which it wishes. In this system, the attribute has five points, (1) interest and the concern, (2) ease, (3) the necessity for authorization, (4) human relations, and (5) time which was shown by 2-3. A student can input importance in three stages about these attributes. Here,

experientially, in order to mitigate the burden of an input, it considered as three stages. Of course, generally, more many numbers of stages should be introduced.

Class organization is determined based on a student's input. An input value is calculated after a student casts his vote. Although the consideration to two or more restrictions or the attribute by the side of a school is also possible, in the prototype system proposed in this paper, we employ linear multi attribute utility function [5]. About each attribute, a multi-attribute utility function is what added all multiple weight and attribute value, is defined, and is the simplest function. In addition, adjustment and change are possible for this function if needed. Fundamentally, it is more desirable to consider the case where it searches for the group by which the sum of a student's utility is maximized. However, in this system, we use two steps of the calculation methods, taking a student's graduation conditions into consideration. First, only the input value of the student of the highest grade is calculated preferentially. Consequently, the group by which the sum of the utility of the student of the highest grade is maximized is determined. Next, the combination by which the sum of the remaining students' utility is maximized is determined.

3.3 Validity of method

We conducted the simulation experiment, in order to show that this method is more effective than the existing method. First, it is assumed that the three numbers of lectures that can be chosen as a certain time exist. A student inputs a multi attribute preferences about each lecture. A utility is calculated based on a student's input value. We used the protocol described above as the determination method. We assumed the following conditions. (1) 100 persons can accommodate each classroom. (2) A student's total is 300 persons. In order to simplify, in this simulation experiment, we made the utility three stages of 0.1 and 0.2 and 0.3. The preference about each lecture of a student used the uniform distribution. Fig3 is the graph shown the result of this simulation. "The determination based on vote ranking, determination based on the order of arrival, and determination based on the order of a grade" which are the method used conventionally was compared with "the method in the prototype system shown in this paper". Consequently, it was shown that the method shown in this paper has improved about 10% rather than the conventional method.

Therefore, it was shown that the method used by the prototype system shown in this paper is more effective than the conventional technique.

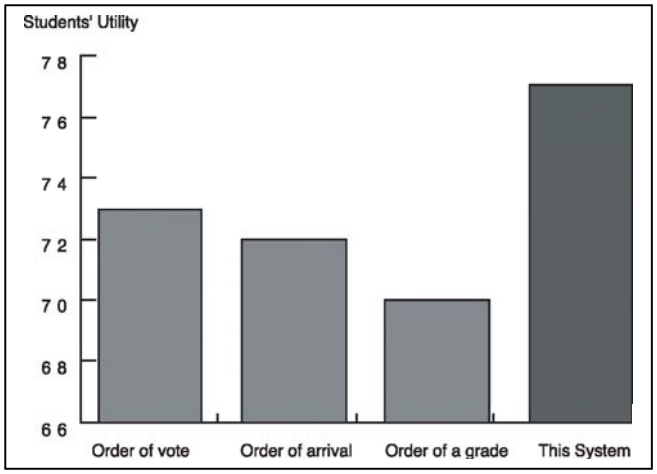

Fig2: The result of a simulation

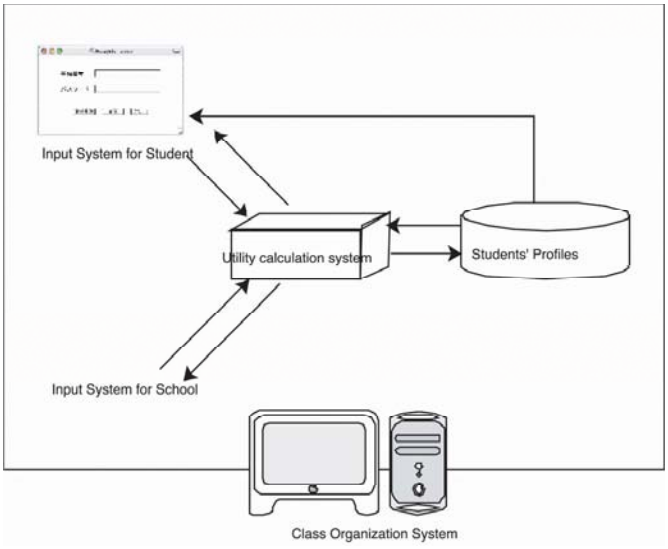

Fig3: System Composition

4. Support System

In this section, we show the prototype of the support system which makes possible the class organization method of an elective subject based on multi-attribute utility theory.

4.1 Outline of our system

The composition of this system is shown in Fig4. The following information is stored in the data file for management as initial data. (1) The subject and the number of units which the student acquired before using this system. (2) The subject in which the student does not acquire yet. That is, in case a student inputs, the information about each user (student) is prepared in advance. For example, a student is shown only the subject that can be chosen, such as forbidding two or more choices of the same subject. Moreover, about the student who can graduate, the number of subjects that should be studied at worst is shown. A prohibition matter and warning are shown based on a student's profile stored in the database. A user (student) inputs an evaluation value for every subject from an input mechanism based on a multi-attribute preference. In the prototype system shown in this paper, three steps of input values exist and importance is chosen about two or more attributes for every lecture. The data in which the student inputted is stored in a data file one by one till deadline time. Furthermore, by the input mechanism for inputting the intention by the side of a school, change of a prohibition matter and warning is possible. In addition, based on the educational consideration by the school side, adjustment of the importance of an attribute and specification of the attribute to which priority is given are also possible. A concrete function is explained in full detail in the following paragraph.

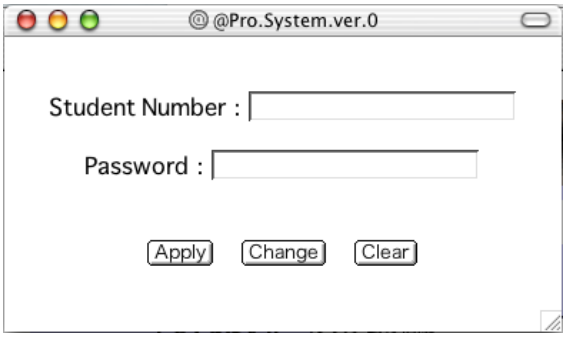

Fig4: Login interface

4.2 User interface

Fig5 and Fig6 are the screens of the application wishing completion by the student (completion candidate). Each user logs in to a system in Fig5. In case a user logs in, he/she inputs a school register number and a password. In case a user inputs the subject for which it wishes newly, he/she pushes the button of "an application of choice." It pushes the button of "change", in changing the hope already inputted on the other hand. However, the application and change after the deadline time in which the school side notified cannot be performed. In Fig6, a completion candidate chooses the subject of choice based on his various preferences and hope. First, a user chooses a lecture name from the leftmost combo boxes. In this system, a user can choose to three lectures. When chose time increases, it is also possible to enable it to vote the number beyond it. This function is explained in full details in the operation screen by the side of a school. A central combo box is a function for choosing the opening day of a week and time about the subject chosen as the user. When the same subject is opened in two or more time, a user can choose the day of the week to wish and time to wish. In addition, this function is being interlocked with the combo box about a lecture name. Therefore, when a lecture name is chosen, the opening day of the week and time that can be chosen are shown. Next, a user determines importance as the selected lecture about two or more shown attributes. A user pushes the button of "an application of choice", after finishing an input. Once a user's input value is stored in a data file. When a deadline time comes, a utility is calculated in a utility calculation Mechanism based on a user's input value. Consequently, the subject each user can study is assigned. Fig7 is a screen for management by the side of a school. It is possible to adjust the calculation method about the importance of multi attributes in which a student can input. The function of "attaching weight to an attribute" is shown below. The calculation that gives importance is possible about the attribute in which the school considered was important based on educational consideration at the time of utility calculation. The function of "giving a priority to an attribute" is shown below. For example, it is possible to assign a lecture first to the student who chose the attribute of "interest and concern" preferentially. The function of "restriction" is the following. Selection of applying restriction of duplication completion etc. is possible. The button of the Fig7 lower right is related with "new registration of a lecture", "change of the lecture room of a registered lecture and change of the number which can be studied", "change of an attribute which a student can input", "abolition of a lecture and curtailment of the elective subject which a student can vote", and "management of vote."

The function of "management of vote" is shown below. The general change about a student's input is possible. For example, a stage division of importance is also included about the calculation method of a utility and attribute selection. The main burdens of the system management by the side of a school are only the inputs of the calculation method of a utility at the end of time for an input by a students, restrictions, etc. By carrying out these inputs in advance, the result of class organization is calculated and outputted simultaneously at the end of end time about a student's input. In use of this system, it can be said that there are few burdens of operation by the side of a school.

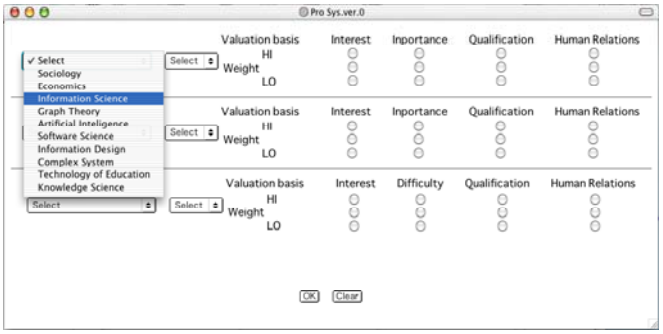

Fig5: Interface for students

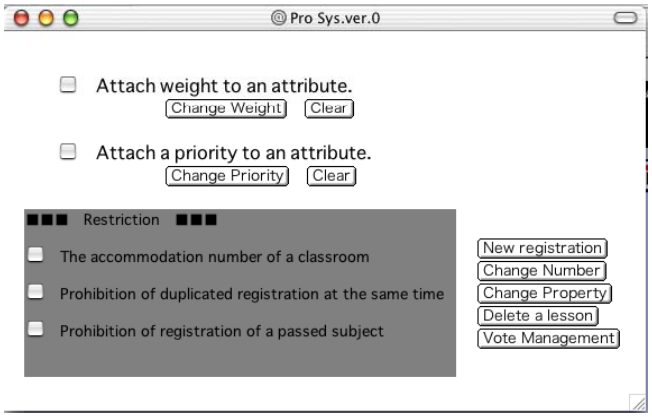

Fig6: Interface for school namagers

5. Conclusion

The system can realize that user' utilities are reflected effectively by our algorithm. In the system, users ㄴ utilities are shown based on a multi-attribute utility theory using the linear calculation. We proposed and indicated effectiveness of an algorithm for class organization. Our system has the following advantages; (1) It realizes class organizations that reflects buyers' multi-attribute preferences. (2) it is easy for school staffs (officers) to manage and use our system because our system calculates users utilities to organize appropriate learners groups. Our future work includes the development of a type of combinatorial/ complement lectures.

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