Classroom Seating Arrangement Based on Optimization Theory

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Structured abstract

BACKGROUND

Even though classroom seating arrangements are an important topic to discuss, it is often determined by using student ID numbers or intentions of homeroom teachers and students. If a teacher succeeds in his or her classroom seating arrangements, the teacher can improve the classroom environment. In our earlier paper, we proposed a method for determining the optimal classroom seating arrangements by using a genetic algorithm. The purpose was to optimize the classroom seating arrangement between two students in the case where one student is sitting on the left side or on the right side of the other student. Relationships between one student and other students sitting around him or her, however, were not taken into consideration.

PURPOSE

The purpose of this study is to propose a method for determining the optimal classroom seating arrangements considering relationships between one student and other students sitting around him or her.

DESIGN / METHOD

In order to determine optimal classroom seating arrangements, a genetic algorithm is applied on the basis of a questionnaire result and the observational analysis of behaviours between students obtained from a coaching interview. Based on the genetic algorithm, we carry out experiments: students take classes sitting on the seats which are determined by the order of student ID numbers and then the students take classes sitting on the seats obtained from the genetic algorithm, and we compare our proposed classroom seating arrangement with a traditional one that is determined by the order of student ID numbers.

RESULTS

From the questionnaire after the class, it is found that many students have some students around them, with whom they can talk about their questions, and they feel more comfortable in the seats obtained from the genetic algorithm in comparison with the seats determined by the order of student ID numbers. It is also found that many students are able to have the seat which they want, and they are able to hear a teacher's voice and to see letters written on the blackboard very well, they are satisfied with their seats. It is confirmed from the experimental results that the proposed method is effective.

CONCLUSIONS

In this study we have proposed the application of the genetic algorithm to find the best classroom seating arrangement. From the experimental results, it is found that each student's satisfaction with our proposed method is higher than the traditional one and that each student is actually comfortable in the classroom because of good relationships with other students. This study will contribute to the improvement of learning effect on each student.

KEYWORDS

Classroom seating arrangement, Genetic algorithm, Matrix crossover

Introduction

Classroom seating arrangements are an important topic to discuss because there are many different ways a teacher can arrange his or her classroom (Adams & Zuckerman 1991). If a teacher succeeds in his or her classroom seating arrangements, he or she may take control over his or her classes (Heindselman, Mentac & Wesler 2007). It is said that classroom seating arrangements are a method for teaching classes well and to improve learning effect on each student (Rennels & Chaudhari 1988).

Classroom seating arrangements have mainly three kinds of arrangements: desk rows, circle or semicircle and clusters. Desk rows is a traditional classroom seating arrangement. The teacher stands in front of the room and all the students' desks face to the front. A circle or semicircle is very different from desk rows. Teachers are able to see all the students in the classroom and all students are able to see the blackboard and the teacher. Clusters, where desks are arranged in groups of four or five, is very conducive to group learning and group work and the students have opportunities to talk with each other.

Generally, one of classroom seating arrangements, desk rows, where students' desks are placed like a matrix, is adopted in Japan and students receiving a higher education usually select their seats with their intentions. In elementary and secondary school, classroom seating arrangements are often determined by the order of student ID numbers at the beginning of the first term to help teachers who want to memorize the names of students as soon as possible. Thereafter, they are often determined by using a lottery or with the intention of the homeroom teacher and students.

If students take lectures by choosing their seats with their intentions, students who have anterior seats have better performances in comparison with other students (Shibuya 1986). If classroom seating arrangements are determined by using a lottery, the students who are assigned anterior seats give more utterance and are more positive about classes than those who are assigned posterior seats (Shibuya 1986). Many students assigned posterior seats complain that it is difficult to hear a teacher’s voice and to see letters written on the blackboard (Shibuya 1986).

It is found from behavioural studies dealing with personal factors of classroom seating arrangements that students who sit in the action-zone tend to get better grades and higher concentration than students who sit in another zone (Rebeta, Brooks & Hunter 1993). The action-zone is defined as the centre of the classroom and the front rows in the classroom (Rebeta, Brooks & Hunter 1993). In addition, the students sitting in the action-zone interact better with teachers in comparison with students sitting on the periphery seats (Burda 1996).

In our earlier paper, we proposed a method for determining the optimal classroom seating arrangements by using a genetic algorithm (GA) (Shin-Ike & Iima 2012). An optimization of the classroom seating arrangements is carried out between two students in the case where one student is sitting on the left side or on the right side of the other student.

In this study we propose a method for determining the classroom seating arrangements considering relationships between one student and other students sitting around him or her. In order to determine the optimal classroom seating arrangements, a GA is applied on the basis of a questionnaire result and the observational analysis of behaviours between students. Our optimization problem lies in determining the classroom seating arrangements in such a way that the minimum of values of the objective function of all students is as large as possible. Five kinds of questions and one of four kinds of personalities of each student and an evaluation value which shows behaviours between every two students apply to the objective function. Based on our proposed classroom seating arrangements, we carried out experiments at a national institute of technology in Japan. This paper reports the results of a survey on the effectiveness of the classroom seating arrangement obtained from the GA.

A method for determining classroom seating arrangements

The problem of determining the optimal classroom seating arrangements is a kind of combinatorial optimization problems, and it is well known that it is difficult to solve the problem (Hous & Stützle 2005). Our optimization problem lies in determining the combination of classroom seating arrangements in such a way that the minimum of the objective functions of all students is as large as possible.

We have p students $\{i;\ i = 1, 2, \ldots, p\}$, where p is the number of students. The solution x for the problem is classroom seating arrangements of students. The evaluation value W_i which is determined when student i evaluates his or her present seat is described by

$$W_i = \sum_{m=1}^{5} \beta_m \, a_{im} \qquad (1)$$

where a_{im} is one of the questionnaire result for student i and β_m is a weight. The evaluation value W_{ij_k} which shows behaviours between students i and j_k, is described by

$$W_{ij_k} = \max\{C_i, P_i, S_i, A_i) + \max\{\, C_{j_k}, P_{j_k}, S_{j_k}, A_{j_k}\} \qquad (2)$$

where C_i, P_i, S_i and A_i are four kinds of personalities for student i and $C_{j_k}, P_{j_k}, S_{j_k}$ and A_{j_k} are four kinds of personalities for student j_k. The evaluation value W which shows behaviours between student i and other students sitting around student i is described by

$$W = \sum_{k=1}^{n} \alpha_k \, W_{ij_k} \qquad (3)$$

where n is the number of students sitting around student i and α_k is a weight.
The objective function is defined by

$$\max \quad Z_i = \min(\mathrm{W} + \gamma W_i) \qquad (4)$$

where γ is a weight.

The flow of GA for solving our optimization problem is as follows.

Step 1 Generate randomly the initial population which consists of plural candidate solutions. Set $g \leftarrow 1$.

Step 2 Pick up two candidate solutions x_1 and x_2 randomly from the current population, and remove them from the current population.

Step 3 Generate two new candidate solutions x_3 and x_4 from x_1 and x_2 according to a procedure called the crossover which is our proposed matrix crossover. In the proposed GA, these new candidate solutions are generated in such a way that the combination of students is inherited.

Step 4 Generate a new candidate solution x_5 by changing a part of x_1. Similarly, generate another new candidate solution x_6 by changing a part of x_2. They are generated by a procedure called the mutation.

Step 5 Select two best candidate solutions from the six candidate solutions $\{x_1, x_2, \cdots, x_6\}$ and add them to the population.

Step 6 If $g = G$, terminate this algorithm and output the best candidate solution as the answer. If not, set $g \leftarrow g+1$ and return to Step 2. The parameter G is given in advance.

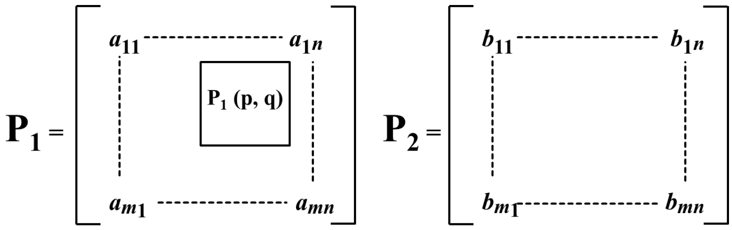

Figure 1: Parent P_1 and P_2

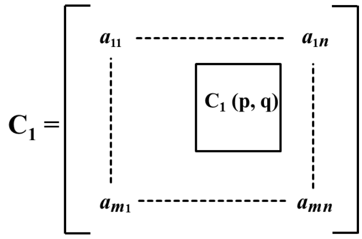

Figure 2: Child C_1 obtained by the matrix crossover

Encoding of chromosomes is one of the problems when we are starting to solve a problem with the GA. Since student ID numbers are used to encode chromosomes, permutation encoding can be used in combination of the classroom seating arrangements. In permutation encoding, each chromosome is a m rows and n columns matrix using student ID numbers.

Crossover and mutation are two basic procedures of the GA. It is no exaggeration to say that performance of the GA depends on them. In this study we propose a new crossover named a matrix crossover. The first child is made by using a procedure shown as follows. First of all, a submatrix of m by n matrix of the first parent is selected randomly. Secondly, the permutation is copied from the chromosome as the first parent except the submatrix selected from the first parent. Finally, the chromosome as the second parent is scanned and if the number is not in the offspring yet, it is added. The second child is also made by using the same procedure as the first child.

Figure 1 shows the first parent P_1 and the second parent P_2 and $P_1(p, q)$ is a submatrix of P_1 formed by deleting row p and column q. Figure 2 shows a child C_1. The chromosome of C_1 except $C_1(p, q)$ is copied from the chromosome of the first parent P_1. The chromosome of $C_1(p, q)$ is added as the chromosome in the case where the number is not in the offspring yet if the second parent P_2 is scanned from the first row and the first column to the m th row and the n th column.

Mutation is an important part of the genetic search to prevent the population from stagnating at any local optima. In this study we adopt order changing as a mutation in permutation encoding. Two numbers belonging to one chromosome are selected randomly and swapped them and the other chromosome is performed in a similar way.

Simulations and experiments of classroom seating arrangements

Fitness value of each student and weight values between personalities of students

Figure 3 shows deskrows. In this figure, $D_1, D_2, \cdots, D_{35}$ and D_{36} show desk numbers and slash marks show aisles in the classroom. T_1 shows a teacher's desk and a blackboard is behind the desk. In desk rows, the number of students sitting around one student ranges from three to eight.

Classroom seating arrangements are optimized to improve the objective functions shown by the equation (4) of all students. An optimization of the classroom seating arrangements is carried out between one student and other students who sit around him or her. Table 1 shows fitness values of two students i and j_k who evaluate their seats, respectively. In this table, a_{i_1} shows an index as to whether student i keeps non-productive talking. a_{i_2} and a_{i_3}show indexes as to whether the student can hear teachers' voice and can see letters which teachers write on the blackboard, respectively. a_{i_4} shows an index of the interest in classes and a_{i_5} shows an index of desire which seat student i wants to sit on. $a_{j_{k1}}$, $a_{j_{k2}}$, $a_{j_{k3}}$,

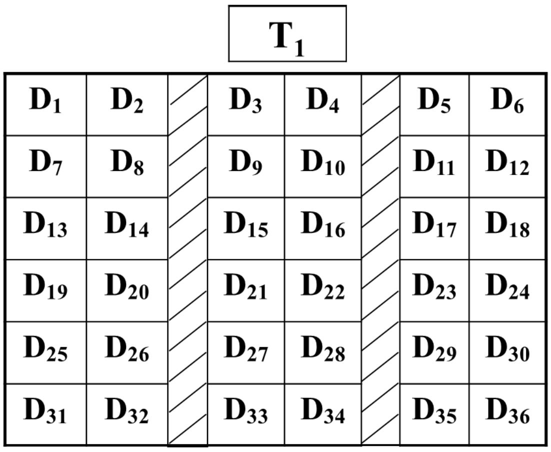

Figure 3: Desk rows in the classroom

Table1: Fitness values of students *i* and j_k for determining classroom seating arrangements

I D	FREQ	HEAR	VIEW	INTE	SEAT
i	a_{i_1}	a_{i_2}	a_{i_3}	a_{i_4}	a_{i_5}
j_k	$a_{j_{k1}}$	$a_{j_{k2}}$	$a_{j_{k3}}$	$a_{j_{k4}}$	$a_{j_{k5}}$

ID: Student ID number, FREQ: Frequency of conversation, HEAR: Hearing range, VIEW: Viewing distance, INTE: Interest of the class, SEAT: First-choice seat location

Table2: Weight values between personalities of students *i* and j_k

α_k	C_i	P_i	S_i	A_i
C_{j_k}	0.10	0.50	0.75	0.25
P_{j_k}	0.50	0.50	0.75	0.25
S_{j_k}	0.70	0.75	1.00	0.75
A_{j_k}	0.25	0.25	1.00	1.00

C: Controller type, *P*: Promoter type, *S*: Supporter type, *A*: Analyser type

$a_{j_{k4}}$ and $a_{j_{k5}}$ show the same indexes of student j_k, as those of student *i*. Each fitness value is translated a zero to one scale.

Table 2 shows weight value α_k shown in equation (3) obtained from coaching interview which is performed with students. Coaching interview is an interactive process that helps each student and groups of students to improve learning effects more rapidly. As a result of coaching interview, students set better goals, take more action and make better decisions. Personalities are divided into four types based on the coaching interview: controller type, promoter type, analyser type and supporter type. Students belonging to the controller type are action-oriented people and tend to perform works according to their own thoughts. Therefore, they dislike instructions from other students above all. Students belonging to the promoter type are fond of challenges to carry out new things, but vitality is one of the lacks in their personality. Students belonging to the analyser type are fond of collecting information and analysing them, but they are weak on a demonstration of affection. Students belonging to the supporter type like to assist other students. They are cooperative and consider human relationships first.

A maximum value of C_i, P_i, S_i and A_i is determined a personality of student *i* and a maximum value of C_{j_k} , P_{j_k}, S_{j_k} and A_{j_k} is determined a personality of student j_k. α_k W_{ij_k} shown in equation (3) is employed to express chemistry of students *i* and j_k. In this equation, α_k is a weight that the chemistry of two students is right or not. For example, if C_i is a maximum value of student *i* and C_{j_k} is a maximum value of student j_k, it is thought that interaction between the students may not occur because they do not prefer to be told what to do each other. That is why α_k is defined 0.1 in Table 2. Other values of α_k shown in Table 2 are defined in a similar way.

The result of the genetic algorithm

In order to simulate the classroom seating arrangement based on our proposed method, thirty six students participate in an experiment. First of all, we carry out a questionnaire to investigate students' feelings toward seating arrangements. The questionnaire is as follows:

1. Do you keep non-productive talking in class?

   A (Yes), B (No)

2. Can you hear a teacher's voice very well?

   A (Very well), B (Well), C (Same as before), D (Poor), E (Worst)

3. Can you see letters which a teacher writes on the blackboard?

   A (Very well), B (Well), C (Same as before), D (Poor), E (Worst)

4. Are you interested in this class?

   A (Very much), B (Much), C (Nothing much), D (No)

5. Which is your best seat in this classroom?

   Please draw a circle on the seat which you want to sit on.

Secondly, on the basis of the questionnaire, the classroom seating arrangements are calculated by using the GA. In our GA, there are three parameters: γ mentioned above, the population size *PS* and the final generation *FG*. The values of them are decided through a preliminary calculation as follows:

$\gamma = 1$, $PS = 50$, $FG = 10{,}000$,

$\gamma = 1$, $PS = 50$, $FG = 100{,}000$.

Each GA is performed ten times with various random seeds. Table 3 shows the final generation, processing time and the value of objective function obtained from calculation results. It is confirmed from this table that the result where *FG* is one hundred thousand is better than the other. This is because the value of objective function is higher than the value in the case where *FG* is ten thousand.

Experiment based on a result of the genetic algorithm

On the basis of the result of GA, experiments are carried out. Participants are the same thirty six students as mentioned above. First of all, the students take classes sitting on their seats which are determined by the order of student ID numbers. Secondly, students take classes sitting on their seats obtained from the result of GA. Finally, we compare our proposed classroom seating arrangements with a traditional one that is determined by the order of student ID numbers.

Figure 4 shows the classroom seating arrangement obtained from the GA in the case where *FG* is one hundred thousand. In this figure, each number shows a student ID number of each student. Students sit on the assigned seats and take a class approximately one hundred minutes, and after the class, they answer a questionnaire.

Table3: Result of GA for the classroom seating arrangement

FG	10,000	100.000
PT	116 (s)	1002 (s)
Z_i	2.04	2.63

FG: Final generation
PT: Processing time
Z_i: Values of objective function
FG: Final generation

T_1

7	30		29	3		23	27
10	20		11	16		17	8
22	5		2	28		9	1
25	34		31	6		35	15
21	26		12	36		32	18
33	24		13	4		19	14

Figure 4: Classroom seating arrangement obtained from the GA (FG = 100,000)

The questionnaire is as follows:

1. Is there anyone who can talk with about your questions around you?
   A (Yes), B (No)
2. Do you sit on the seat which you want to?
   A (Yes), B (Near the seat), C (No)
3. Can you hear a teacher's voice very well?
   A (Very well), B (Well), C (Same as before), D (Poor), E (Worst)
4. Can you see letters written on the blackboard?
   A (Very well), B (Well), C (Same as before), D (Poor), E (Worst)
5. Are students quieter than before in the class?
   A (Much quieter), B (Quieter), C (Same as before), D (A bit loud buzz), E (Loud buzz)
6. Do you concentrate in class in the present seat?
   A (Very much), B (Much), C (Same as before), D (Nothing much), E (No)
7. Are you satisfied with your seat in the classroom?
   A (Very much), B (Much), C (Same as before), D (A bit unsatisfied), E (No)
8. How do you feel sitting on the present seat in comparison with the former seat?
   A (Much better), B (Better), C (Same as before), D (Worse), E (Much Worse)

Table 4 shows a result of the questionnaire for the classroom seating arrangement. In this table, the first column shows the numbers of the questions mentioned above and A, B, C, D

Table 4: Result of questionnaires for classroom seating arrangement (*FG* = 100,000)

Item	A (%)	B (%)	C (%)	D (%)	E (%)
1	54.0	46.0	0.0	0.0	0.0
2	11.0	62.0	27.0	0.0	0.0
3	34.0	27.0	31.0	8.0	0.0
4	34.0	19.0	35.0	8.0	4.0
5	31.0	38.0	31.0	0.0	0.0
6	12.0	15.0	65.0	4.0	4.0
7	4.0	19.0	46.0	16.0	15.0
8	19.0	27.0	35.0	11.0	8.0

Table5: Good-Poor analysis of the result of GA (*FG* = 100,000)

Item	G (%)	P (%)
1	54.0	46.0
2	73.0	0.0
3	61.0	8.0
4	53.0	12.0
5	69.0	0.0
6	27.0	8.0
7	23.0	31.0
8	46.0	19.0

and E in the first row shows the alternatives of each question. It is found from the first question that 54.0 % of the students have some students around them, whom they can talk with about their questions and that they feel more comfortable in comparison with the former seats. In the second question, 73.0 (11.0 + 62.0) % of the students are able to sit on or near the seat which they want to. In the third question, since 61.0 (34.0 + 27.0) % of the students choose the answer A or B from the alternatives, it is thought that they are able to hear a teacher's voice well. In the fourth question, 53.0 (34.0 + 19.0) % of the students reply that they are able to see the letters well written on the blackboard. But 12.0 (8.0 + 4.0) % of the students reply that they are not able to see them well. It is thought that one of the reasons is a difference of body length between the student and the other student who sit in front of the student. In the fifth, sixth and seventh questions are unrelated to the objective function defined by equation (4). These questions are used to survey the situation in the classroom and satisfaction levels of the students in the classroom seating arrangement. It is found from the fifth question that 69.0 (31.0 + 38.0) % of the students feel the students are quieter than before and in sixth question 27.0 (12.0+15.0) % of students feel they are able to concentrate in class. It is found from the seventh question that 23.0 (4.0 + 19.0) % of the students are satisfied with their seats obtained from the GA. In the eighth question, 46.0 (19.0 + 27.0) % of the students feel better in their seats obtained from the GA.

Table 5 shows a good-poor analysis of the questionnaire for the classroom seating arrangement in the case where *FG* is one hundred thousand. In this table, the first column shows numbers of the questions the same as Table 4, and G and P in the first row stands for good and poor for Good-Poor analysis, respectively. In this table, it is found from the first question that the ratio of Good and Poor is fifty four to forty six. This ratio of Poor is larger than any other ratios of Poor in Table 5. It is thought that a key reason is that some students are absent from lectures and another some students who are in the class are not able to find students to talk about their questions. In the second to fifth question, since the ratios of Good are more than fifty, it is thought that most students sit on their satisfying seats and they are able to hear a teacher’s voice and to see letters written on the blackboard very well. In the sixth question, it is found that the number of the students who can concentrate in class increases in comparison with the former seats. From the results of the seventh and eighth questions, it is thought that many students feel better in the present seats than the seats which are determined by the order of student ID numbers. But the students’ satisfaction on the proposed classroom seating arrangement obtained from the GA is not so high. It is thought that this is because the present seats are determined from the GA but students have a little bit complaint about the classroom seating arrangement.

Conclusion

In this paper we have proposed a method for determining the classroom seating arrangements considering relationships between one student and other students sitting around him or her. A GA is applied to find the best classroom seating arrangement. The objective function is defined by the students’ requests obtained from the questionnaire related to the students' feelings toward seating arrangements. On the basis of the results of the questionnaire, the classroom seating arrangements are calculated by using the GA and we carried out experiments at a national institute of technology in Japan. Students take classes on the seats determined by the order of student ID numbers and on the seats obtained from the GA. Then we compare our proposed classroom seating arrangement with a traditional one. From the questionnaire of the classroom seating arrangements, it is found that satisfaction of each student for our proposed method is higher than that for the traditional one. It is also found that each student is actually comfortable in the classroom because of the relationships with other students. It is confirmed from the experimental results that the proposed method was effective. This method can determine the classroom seating arrangements by a simple process in a short time. When teachers make classroom seating arrangements to improve the learning effect on each student, this research will help them to improve it.

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