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Students Group Formation for an English Conversation Class Using 0-1 Integer Linear Programming

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ABSTRACT

In this paper, we illustrate the application of 0-1 integer linear programming to form a small discussion group among students of an English conversation class at Universiti Utara Malaysia. The model was developed to ensure that each group consists of not more than four students, the probability for each group to be actively engaged in conversation activities is high, each group consists of a mix of gender and race-composition, as well as some other specific requirements set by the instructor of the class. The optimal solution was obtained with the help of Lingo 11. The same approach can be extended to solve some other classroom management problems.

1. Introduction

One of the main functions of The Language Centre at Universiti Utara Malaysia (UUM) is to prepare its international students who are not quite proficient in English to a satisfactory level that enables them to survive the university life. Some of the classes offered are English grammar class, English reading and writing class, and English conversation class. For the previous-July 2016/2017 academic session, three conversation classes were offered.

In one of the classes, the assigned class instructor decided to create a lot of various small group activities to encourage students to interact with each other, which has been proven by researchers to be an effective way of improving the students' communication skills [1]. As such, at the beginning of the semester, the instructor requested the students to form a group of three and the students were given freedom to choose their own group members. The class initially consisted of 30 students from various backgrounds and countries.

Unsurprisingly, most students preferred to be in a group that they felt comfortable in, i.e. the group that had at least one other member from the same country. As a result, during the group activities, although there were active conversation activities going on among the students, the

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conversation however occurred in languages other than English, thus defeating the intended objective for the creation of the group. To eliminate the problem, the instructor decided to rearrange the group composition so that if possible, in each group, there would not be any two members that speak the same language(s) (other than English, of course). At the time when the instructor decided to do so, the class received another two students, making it 32 students in total. Therefore, according to the instructor, it would be acceptable for some groups to consist of more than 3 students but not more than 4 students because it would be inappropriate to have a group of only 2 members in it. However, at the same time, the instructor also wanted to ensure that the number of groups having 4 members were minimized. In addition, there were also a few concerns to be addressed as follows:

i. Two of the students, Aisya and Salem, must not be assigned to the same group.
ii. In addition, Salem also could not be in the same group with Indri.
iii. All groups must have a combination of male and female students.
iv. Some of the students are very timid while some are very talkative. Thus, ensuring that each group interaction becomes lively is crucial.

Table 1
Student's name, gender, and language(s) spoken

			Language(s) Spoken						
No.	Name	Gender	Arabic	Indonesian	Mandarin	African	Thai	Tamil	French
1	Salem	M	/						
2	Osama	M							/
3	Fatima	F	/						/
4	Indri	F		/					
5	Rangga	M		/					
6	Ratchanok	F					/		
7	Aaisya	F				/			
8	Xian Yi	F			/				
9	Ma Mei	F			/				
10	Churugi	M				/			
11	Beraheng	M		/			/		
12	Chanya	F					/		
13	Aragesan	M						/	
14	Abo Salem	M	/						
15	Rahmah	F		/			/		
16	Stanley	M				/			
17	Alajuwon	M				/			
18	Chairany	F		/					
19	Rattapong	F					/		
20	Praba	M						/	
21	Xie Peng	F			/				
22	Taufeeq	M	/						
23	Hui Feng	F			/				
24	Jia Yie	F			/				
25	Stefani	F							/
26	Joseff	M				/			
27	Ishmael	M	/						
28	Leyla	F	/						
29	Bilal	M	/						
30	Hossein	M				/			/
31	Sompop	M					/		
32	Chougi	M				/			

At one glance, the problem described above could easily be modelled and handled as a 0-1 integer linear programming (0-1 ILP) model. However, to fulfil all the requirement as stated by the instructor, two sets of information were required. The first set of information involves the details on the gender, and the language(s) spoken by the students. The required information are as given in Table 1.

The second set of information was on the probability for each student to actively participate in a group discussion activity. The information, as given in Table 2 was gathered based on the instructor's personal estimation.

Table 2
Student's probability to participate in group discussion activities

Student	Probability	Student	Probability
Salem	100%	Alajuwon	85%
Osama	80%	Chairany	50%
Fatima	35%	Rattapong	40%
Indri	50%	Praba	100%
Rangga	75%	Xie Peng	50%
Ratchanok	40%	Taufeeq	80%
Aaisya	60%	Hui Feng	35%
Xian Yi	30%	Jia Yie	20%
Ma Mei	20%	Stefani	85%
Churugi	70%	Joseff	90%
Beraheng	60%	Ishmael	75%
Chanya	40%	Leyla	60%
Aragesan	90%	Bilal	90%
Abo Salem	80%	Hossein	60%
Rahmah	75%	Sompop	75%
Stanley	90%	Chougi	60%
Average group probability = 64.06%			

Having all the needed information, the 0-1 ILP model for the problem was developed.

2. 0-1 Integer Linear Programming Model

0-1 ILP model is an extension of the Integer Linear Programming (ILP) model. The general mathematical formulation for a 0-1 ILP model is as follows

$$Maximize \sum_{j=1}^{n} c_j x_j$$

Subjected to

$$\sum_{j=1}^{n} a_{ij} x_j = b_i \quad \forall\, i = 1,2,.....,m$$
$$x_j \geq 0 \; and \; binary \quad \forall\; j = 1,2,...,n \qquad (1)$$

The model has been used to solve many types of problems such as resource allocation [2-3], assignment problem [4-5], transportation problem [6-7], timetabling problem [8-9] and network problem [10-11], to name a few. Depending on the size and nature of the problem, the model can be

solved either optimally via branch and bound technique or heuristically via various heuristic techniques such as the meta-heuristics, or any construction-based heuristics [12-13].

3. Solution Approach

The steps in modelling the group composition problem were as follows:

Step 1: Model the problem as a 0-1 ILP model.

- Decision Variables:

$$x_{ij} = \begin{cases} 1 & if\ student\ i\ is\ assigned\ to\ group\ j \\ 0 & otherwise \end{cases}$$

where i = 1,2,3,…,32 and j = A,B,C,..,J

- Objective function: Maximize total number of groups formed

Max Total Groups = $\sum_{i=1}^{32} \sum_{j=A}^{J} x_{ij}$

Subject to these following constraints:

i. Each student must belong to a group.

$$\sum_{j=A}^{J} x_{ij} = 1 \quad \forall i = 1,2,3,...32$$

ii. Aisya and Salem cannot be in the same group.

$$x_{1j} + x_{7j} \leq 1 \quad \forall j = A, B, C, ..., J$$

iii. Indri and Salem cannot be in the same group.

$$x_{1j} + x_{4j} \leq 1 \quad \forall j = A, B, C, ..., J$$

iv. All groups must be a combination of male and female students. This can be handled by adding two constraints: (1) there should be at least 1 male student in each group, and (2) there should be at least 1 female student in each group.

$$x_{1j} + x_{2j} + x_{5_j} + x_{10j} + x_{11j} + x_{13j} + x_{14j} + x_{16j} + x_{17j} + x_{20j} + x_{22j} + x_{26j} + x_{27j} + x_{29j} + x_{30j} + x_{31j} + x_{32j} \geq 1 \quad \forall j = A, B, C, ..., J$$

$$x_{3j} + x_{4j} + x_{6_j} + x_{7j} + x_{8j} + x_{9j} + x_{12j} + x_{15j} + x_{18j} + x_{19j} + x_{21j} + x_{23j} + x_{24j} + x_{25j} + x_{28j} \geq 1 \quad \forall j = A, B, C, ..., J$$

v. Each group must consist of not more than 4 students.

$$\sum_{i=1}^{32} x_{ij} \leq 4 \quad \forall j = A, B, C, ..., J$$

vi. Two students speaking the same language cannot be in the same group.

Arabic $x_{1j} + x_{3j} + x_{14j} + x_{22j} + x_{27j} + x_{28j} + x_{29j} \leq 1 \quad \forall j = A, B, C, ..., J$

Indonesian $x_{4j} + x_{5j} + x_{11j} + x_{15j} + x_{18j} \leq 1 \quad \forall j = A, B, C, ..., J$

Mandarin $x_{8j} + x_{9j} + x_{21j} + x_{23j} + x_{24j} \leq 1 \quad \forall j = A, B, C, ..., J$

African $x_{7j} + x_{10j} + x_{16j} + x_{17j} + x_{26j} + x_{30j} + x_{32j} \leq 1 \quad \forall j = A, B, C, ..., J$

Thai $x_{6j} + x_{11j} + x_{12j} + x_{15j} + x_{19j} + x_{31j} \leq 1 \quad \forall j = A, B, C, ..., J$

Tamil $x_{13j} + x_{20j} \leq 1 \quad \forall j = A, B, C, ..., J$

French $x_{2j} + x_{3j} + x_{25j} + x_{30j} \leq 1 \quad \forall j = A, B, C, ..., J$

vii. In order to ensure active group participations, the group average score for probability to interact should be between 50 percent, to 70 percent. The range was set based on the average class probability to interact, which is 64.06 percent.

$$\frac{\sum_{i=1}^{32} p_i x_{ij}}{\sum_{i=1}^{32} x_{ij}} \geq 50 \quad \forall j = A, B, C, ..., J$$

$$\frac{\sum_{i=1}^{32} p_i x_{ij}}{\sum_{i=1}^{32} x_{ij}} \leq 70 \quad \forall j = A, B, C, ..., J$$

Step 2: Solve the model. Since the problem size was manageable (i.e. the 0-1 ILP-model consists of only 330 binary variables and 173 constraints) the problem could be solved optimally using any ILP-software. In our case we used *Lingo 11*.

4. Results

The optimal result obtained is as follows:

Table 3
Students in group A

Student	Gender	Language spoken	Probability to interact
Salem	M	Arabic	85
Xie Peng	F	Mandarin	50
Hoessin	M	African/French	60
Average probability to interact			65

Table 4
Students in group B

Student	Gender	Language spoken	Probability to interact
Osama	M	French	80
Aaisya	F	African	60
Chanya	F	Thai	40
Bilal	M	Arabic	90
Average probability to interact			67.5

Table 5
Students in group C

Student	Gender	Language spoken	Probability to interact
Xian Yi	F	Mandarin	30
Aragesan	M	Tamil	90
Chougi	M	African	60
Average probability to interact			60

Table 6
Students in group D

Student	Gender	Language spoken	Probability to interact
Fatima	F	Arabic/French	35
Beraheng	M	Indonesian/Thai	60
Stanley	M	African	90
Average probability to interact			61.67

Table 7
Students in group E

Student	Gender	Language spoken	Probability to interact
Alajuwon	M	African	85
Chairany	F	Indonesian	50
Ishmael	M	Arabic	75
Average probability to interact			70

Table 8
Students in group F

Student	Gender	Language spoken	Probability to interact
Indri	F	Indonesian	50
Taufeeq	M	Arabic	80
Stefani	F	French	85
Jia Yie	F	Mandarin	20
Average probability to interact			58.75

Table 9
Students in group G

Student	Gender	Language spoken	Probability to interact
Rangga	M	Indonesian	75
Ratchanok	F	Thai	40
Joseff	M	African	90
Average probability to interact			68.33

Table 10
Students in group H

Student	Gender	Language spoken	Probability to interact
Ma Mei	F	Mandarin	20
Churugi	M	African	70
Sompop	M	Thai	75
Average probability to interact			55

Table 11
Students in group I

Student	Gender	Language spoken	Probability to interact
Praba	M	Tamil	100
Leyla	F	Arabic	60
Rattapong	F	Thai	40
Average probability to interact			66.67

Table 12
Students in group J

Student	Gender	Language spoken	Probability to interact
Abo Salem	M	Arabic	80
Rahmah	F	Indonesian/Thai	75
Hui Feng	F	Mandarin	35
Average probability to interact			63.33

Only two groups, namely group B and group F has 4 students each. The remaining groups consists of 3 students each. Group H has the lowest average probability to interact with a value of 55 while group E has the highest average probability to interact with a value of 70.

5. Conclusion

In this paper, we showed how 0-1 ILP can easily be applied to solve a classroom management problem. In our case, the problem was to assign students to a small discussion group that could increase the probability of active involvement by the group members. Although the optimal result gave a satisfactory solution, the gap between the lowest group average probability to interact with the highest group average probability to interact was rather large (i.e. 55 versus 70). Perhaps, a better optimal solution could be obtained by adjusting and setting the group probability range in the model constraint to become smaller.

The same approach can be extended to solve some other classroom management problems as exhibited in previous studies by Behestian-Ardekani and Mahmood in [14] and Engku and Razamin in [15] in assigning both experienced and inexperienced students in different project groups, Lawrence, Lawrence and Reeves in [16] and Yang in [17] in assigning teaching staff to courses, as well as Reeves and Hickman in [18] in assigning MBA students to summer field study project team.

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