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0-1 Integer Programming Formulation for Solving the Student Project Assignment Problem

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Abstract: The assignment process for graduated students at the beginning of each semester is an important process for all academic programs at Benghazi University. This paper presents a model that includes a number of constraints relating to the minimum and maximum number of students in each academic program and the prerequisites and corequisites for each project in each academic program. The objective is to determine a way to assign students to projects according to their preferences. A linear grade function that represents the preferences of each student is introduced to be maximized. A 0-1 integer programming formulation is proposed that was implemented using data from the 2008 fall and 2009 spring semesters in the Industrial Engineering and Manufacturing Systems Department at the University of Benghazi in Benghazi, Libya. The assignment solutions were obtained using different preference criterions and were then compared with the solutions previously obtained using a manual system.

Keywords: Integer programming, assignment, Lingo program

1. INTRODUCTION

The process of assigning students to their preferred projects is done through the use of a certain criterion. Each student orders the available projects according to their preference on the supplied form. The student is assigned to his preferred project if he has completed its prerequisites and corequisite courses and if the number of students in the project has not exceeded the maximum number permitted. For the prerequisites courses, the student must first pass them successfully, while for the corequisite courses, the student must be enrolled in it at the same time or have taken it previously. Students who do not submit a preference form will be assigned to any project after all the students who filled in the form are scheduled. The criterion used to prioritize the preferences of the students is their average grades or scores. Students with the highest grades or scores will be assigned first to their preferred projects. The average grade is the overall grade of the student divided by the number of semesters he has been enrolled at the university. The average score is the overall score divided by the number of semesters that the student has studied at the university. The manual technique that was traditionally used to assign students to projects is tedious and time-consuming. In addition, it has become more difficult with the increasing number of students. Therefore, this paper presents an integer programming formulation to solve this problem. The specific constraints relating to the graduate student's enrolment data and the permitted number of students in each project will be taken into consideration.

(Amit and Anila,2010) Two methods were proposed to solve such type of fuzzy assignment problems and fuzzy travelling salesman problems . The fuzzy assignment problems and fuzzy travelling salesman problems which were solved by using the proposed methods, which were the optimal solution , and simple to understand and apply .

((Trivikram, Anastasia & Frits, 2012) have considered the multi-level bottleneck assignment problem (MBA) and were described in the previous book ''Assignment Problems'' by Burkard et al. (2009), although its complexity status is called open and have viewed the problem as a special case of a bottleneck m-dimensional multi-index assignment problem, but complexity status it was settle, and they have given approximation algorithms and in approximability results, depending upon the completeness of the underlying graph.

Hadi (2012) has proposed approach as a systematic procedure, simple and can be used for all types of assignment problem with maximizing or minimizing objective functions.

Pavlo and Panos (2007), have represented extensively in the previous studies were used the methods of probabilistic analysis by the assignment problems, and many important problems in operations research and computer science can be formulated as assignment problems. Ralf and Olga(2012) presented an extended integer linear programming formulation which implies by using the hypergraph assignment problem (HAP) is the generalization of assignments from directed graphs to directed hypergraphs and proved that all problems with a simple hyperarc size and hypergraphs with a special partitioned structure the HAP is NP-hard and APX-hard.

Eric and Estelle (2012) used theory and field data to study the draft mechanism to determine courses at Harvard Business School and identified a new relationship between fairness ,design a new draft that reduces these costs and drawed several broader lessons for market design.

2. ALGORITHM

A 0-1 integer programming will be used to formulate and solve the problem of assigning students to projects. This algorithm assigns a set of students to a fixed number of projects. The required data include the allowed number of students in each project, each student's preferences, and enrolment data of graduate students. The objective of this study is to assign the graduate students in the Industrial and Manufacturing Systems Engineering Department to groups for the available projects.

2.1 Problem formulation

The objective function is given as:

$$Max \quad X_0 = \sum_{i=1}^{n}\sum_{j=1}^{P} C_{ij} x_{ij} \qquad (1)$$

The constraints are as follows:

1. Student assignment constraints:

$$\sum_{j=1}^{P} x_{ij} = 1 \qquad i = 1,2,....,n \qquad (2)$$

2. Upper and lower constraints:

$$\sum_{i=1}^{n} x_{ij} <= U_j \qquad \sum_{i=1}^{n} x_{ij} >= L_j \qquad j = 1, 2, 3, ...P \qquad (3)$$

3. Prerequisite and corequisite courses constraints

$$x_{ij} = 0 \qquad (4)$$

4. Student pre-assignment constraints

$$x_{ij} = 1 \qquad (5)$$

$$x_{ij} = 0 \text{ or } 1$$

Where:

n =	Number of students
P	Number of projects
U_j	Maximum number of students assigned to project j
L_j	Minimum number of students assigned to project j
C_{ij}	Preference-criterion coefficient of student i in project j

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

The first term in the objective function (1) represents the preference-criterion coefficient while indicating the priority of students for selecting their preferred projects. This criterion may vary from semester to semester.

Constraints (2) ensure that each student is assigned to only one project. Constraints (3) ensure that the number of students assigned to any project must be within certain department limits. Constraints (4) ensure that student is not assigned to a project when he did not complete the prerequisites or corequisites courses. Constraints (5) ensure that certain students (pre-assignments) are assigned to their specific project.

3. IMPLEMENTATION

3.1 IE department

A regular student enrolled in the Department of Engineering at the University of Benghazi is expected to successfully complete 4 years of study (eight semesters) as part of the B.Sc. degree requirements.

The student must complete the general engineering courses taken in the Engineering Science Department during the first year (two semesters) of study before being assigned to another specialized department, taking his preferences into consideration. In addition, the student is expected to successfully complete a final year engineering project (IE415/IE448, IE416/IE449). At the beginning of each semester, the assignment of students to their preferred projects is prepared manually by an appointed committee consisting of several staff members.

The data for this study was taken from the projects offered in the Industrial Engineering Department in the 2008 to 2009 school year (two semesters). In the fall semester, there were 48 students and 13 projects. The grade criterion gave priority to students with higher average grades. The minimum and maximum numbers of students that could be assigned to each project was two and four, respectively. In the spring semester, there were 29 students and 11 projects. The score criterion gave priority to students with higher average scores. The minimum and maximum numbers of students that could be assigned to each project was two and three, respectively. Three students were already assigned to project 11. These students did not fill out the preference form and were not included in the ordering list.

3.2 The manual system

After each student ordered the available projects according to their preferences, the manual system would assign students according to the grade or score criterion. The student would then be assigned to his preferred project if he had completed the prerequisites and corequisite courses and if the number of students did not exceed the upper limit for the project. The steps of the manual system to assign students to a project were as follows:

Step1: Order the students according to the criterion

Step2: Select the first student on the ordering list and start with their first preferred project

Step3: If the student had completed the prerequisite and corequisite courses and the k^{th} preferred project was not full, then go to step 4; otherwise, go to step5.

Step4: Assign the student to k^{th} preferred project and go to step 6.

Step5: Select the project in the next preference (k) and go to step 3.

Step6: If all students are assigned, stop; otherwise, go on to step 2.

3.3 Results

3.3.1 Results of the manual system

The manual system ordered the students according to their average grades and gave priority to the students with higher average grades for the 2008 fall semester. Project assignment was done within the conditions for the first students in the ordering list. One problem with the manual system lay in determining if all prerequisites and corequisite courses had been completed for the students at the end of the list; if they had not been completed, then the committee changed the prerequisites courses to corequisite courses, which meant that the students with the higher grades were then not assigned to these preferred projects. Therefore, this assignment process was neither accurate nor just.

For the 2009 spring semester, the students were ordered according to their average score, and student assignments were made according to this criterion; however, the manual system ran into the same problem as before. Last students in the ordering list only had a few projects left that they needed to take, but these projects had already been filled by the students with higher scores. Therefore, these students were assigned to other projects for which they had not completed the prerequisites and corequisite courses. In the manual system, the value of average grade achievement of all student’s preferences is 62.83 in fall 2008 while the value of average score achievement of all student’s preferences in spring 2009 is 384.45**.** Also, in the 2008 fall semester, 10 projects were full and the 2 other projects only had a few students. In the 2009 spring semester, 6 projects were full and the other projects only had 2 students each.

3.3.2 Results of an integer linear formulation

In this study, a mathematical model was developed to solve the student-project assignment problem in the Industrial and Manufacturing Systems Engineering Department for the 2008 fall and 2009 spring semesters. The problem formulations for the two semesters were solved using the Lingo program. The mathematical model for the fall semester had 624 decision variables, 180 constraints for the prerequisites and corequisite courses conditions, 48 constraints to ensure that each student was assigned to one project, and 26 constraints for project limits. The value of average grade achievement was 81.45, 10 projects were full, one project was at the lower limit of students, and 2 projects had 3 students. In the spring semester, the mathematical model had 260 decision variables, 46 constraints for prerequisites and corequisite course conditions, 26 constraints to ensure that each student was assigned to one project, and 20 constraints for project limits. The value of average score achievement was 1121.27, 6 projects were full, and the rest of projects only had 2 students each.

3.4 Comparison between the manual system and the integer linear programming solution

The proposed algorithm was more successful at assigning all students to projects depending on their preferences than the manual system (see Tables 1 and 2). The numbers in these tables refers to the number of students for which k^{th} preference was achieved.

Table 1. Comparison between the manual system and integer linear programming solutions in the 2008 fall semester

K^{th} Preference	Integer linear programming	Manual system
1	27	21
2	12	12
3	2	4
4	2	2
5	1	-
6	-	2
7	2	3
8	-	-
9	-	2
10	1	-
11	-	-
12	1	2

Table 2. Comparison between the manual system and integer linear programming solution in the 2009 spring semester

Kth Preference	Integer linear programming	Manual system
1	12	11
2	4	4
3	3	1
4	1	2
5	2	3
6	1	1
7	-	-
8	1	1
9	-	-
10	2	3

4. CONCLUSION

From the above results, the manual system did not adequately handle the prerequisites and corequisite course conditions. These constraints were difficult to achieve manually. Also, the committee complained about the difficulty of achieving these constraints each semester. Thus, to solve this problem and to make the work of the manual system easier, an integer programming system was developed to formulate and solve these problems. The objective was to maximum achievement of the project preferences of students with four types of constraints.

As can be seen in the comparison between the integer linear programming and the manual system, the top preference of most students was achieved using the proposed mathematical model as opposed to the manual system because this algorithm provided the optimal solution for this problem. The integer linear formulation can more easily handle the problem of the prerequisitesand corequisite courseconditions. This model can easily be adapted to solving the student-project assignment problem for any semester by setting the coefficient of the objective function independent based on average grades, average scores, or student preferences, or by adding conditions or constraints.

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