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A new Application of Assignment Problems Using Three Techniques with it Comparison

Fatema A. Sadiq [a]*, Mayada N.Mohammedali [b], Raghad I.Sabri [C]

[a] *Mathematics and Computer Applications, Applied Sciences, University of Technology, Iraq.Email: fatema.a.sadiq@uotechnology.edu.iq*

[b] *Mathematics and Computer Applications, Applied Sciences, University of Technology, Iraq.Email: mayada.n.mohammedali@uotechnology.edu.iq*

[c] *Mathematics and Computer Applications, Applied Sciences, University of Technology, Iraq.Email: raghad.i.sabri@uotechnology.edu.iq*

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ABSTRACT

The assignment models are one of the effective operations research techniques for enhancing the educational process and obtaining the desired learning outcomes. Universities organize the criteria for distributing accepted students in accordance with the central admission plan issued by the Ministry of Higher Education to their departments based on of the student's qualifications represented in the total of his grades in the general examinations for secondary studies as a criterion that qualifies him to compete with other students, in addition to the student's choices and the department plan. In this paper, we discuss the assignment problem (AP) in the allocation of students to college departments depending on the degree of comparison. Three techniques of assignment problem were used, namely; the Hungarian technique, the Alternative technique, and the new technique presented by Haleemah Jawad Kadhim in 2021, to find the best allocation

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∗Corresponding author Fatema A. Sadiq

Email addresses: *Fatema.A.Sadiq@uotechnology.edu.iq*

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1. Introduction

A specific type of transportation problem is the assignment problem, which arises when the number of sources (jobs) and the number of activities (machines, people, etc.) are equal. It results from various decision-making circumstances linked to work or task assignments in daily activities [1], [2]. Assignment model comes under linear programming, which has to do with allocation of work to machines ,and persons to place. Basically, assignment model has two objectives either to minimize or maximize [3]. In the assignment model, each task must be assigned on one-on-one basis; a machine or human cannot have more than one work or job allocated to them. Each assignment problem is supplemented by a table or matrix, where the rows often contain the items or persons we want to assign and the columns comprise the things or tasks we want to assign. The values in the table or entries in the matrix are costs related to a certain assignment. The assignment problem is a useful tool that is accepted and widely used all over the world for addressing problems in real life. It may be used to assign tasks to machines, operators to machines, salespeople to territories, workers to supervisors, courses to lectures, and engineers to building sites, among other things, with the goal of minimizing or maximizing depending on the kind of problem [4-8].

The Hungarian method established by mathematicians D. Konig and E.Egervary [9, 10] is one of the many computational methods recommended for dealing with problems. The alternative method was created by [11] which is the second algorithm for solving an assignment issue to find the best answer. The third algorithm to find the best answer to the assignment problem is the new technique method that was proposed in [12]. In this paper, the efficiency of the three algorithms including the Alternative, Hungarian and the new technique is utilized in the case study of students and departments to allocate one student to one department in such a way that the degree of comparison is maximize. The remainder of the present article is organized in the following way: In section two, the mathematical model of an assignment problem with a case to the students and departments in Collage of the Sciences one of the universities of Iraq is given. Section three uses the steps of the Hungarian Method to solve the suggested AP while an Alternative technique is provided to solve such problem in section four. Section Five solve the proposed AP using the steps of the new technique. Finally, the conclusion is listed in section six.

2. The Case Study and its Mathematical model

In this case study, the data* of four students of the 2021 results who were admitted to the College of the Science in of the University of Iraq were taken according to the central admission controls and conditions, and also according to their marks in the secondary study of six subjects : Biology, Arabic, English, Mathematics, Chemistry, Physics, The students were distributed to the departments after their arrangement from highest to lowest according to their total scores in the general exams for secondary studies and the plan developed for each department, were as shown in the table 1.

Table 1- Distribution of students to departments based on the total grades of different subjects

students	Arabic	English	Biology	Mathematics	chemistry	physics	total	Departments
s_1	94	87	87	91	92	82	533	chemistry
s_2	74	55	82	78	74	76	439	Biology
s_3	83	92	91	64	90	75	495	physics
s_4	90	74	84	86	66	77	477	Mathematics

The formal definition of the studied balanced assignment problem is : given two sets, four students s_1, s_2, s_3, s_4 and four departments including chemistry, Biology, physics, and Mathematics to allocate one student to the one department, suppose the degree of comparison is equal the total scores of the general examinations for secondary

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* The data were collected from one of the universities of Iraq/collage of Sciences, Registration Division

studies plus the grade of the subject for the required department, for the students i for the department j is c_{ij}. Our problem now is how to allocate only one student to one department in order to maximize the degree of comparison in the optimal distribution of students to departments, and this helps to increase the level of student scientifically achievement and thus improve the educational level. The mathematical model of the proposed assignment problem can be written as follows:

$z = \sum_{j=1}^{n} \sum_{i=1}^{m} c_{ij} x_{ij}$

n = Number of departments

m = Number of students

i= Row number representing students

j = Column number representing department

= The degree of comparison of the student i for allocated to the department jc_{ij}

$$x_{ij} = \begin{cases} 1 & \text{if } i^{th} \text{student s is allocated to } j^{th} \text{ department} \\ 0 & \text{otherwise} \end{cases}$$

Z = Objective Function (Maximization)

Subject to the constraints

(Only one student s should be allocated to one department) $\sum_{i=1}^{m} x_{ij} = 1 \quad for\ j = 1,2, \dots, n$

(Each student for one department)$\sum_{j=1}^{n} x_{ij} = 1 \ \ for\ i = 1,2, \dots, m$

The number of students to be allocated together with the number of departments according to the degree of comparison are given in Table 2

Table 2- The degree of comparison of the student for each departments

Departments / **Students**	**Biology**	**Math**	**chemistry**	**physics**
s_1	620	624	625	615
s_2	521	517	513	515
s_3	586	559	585	570
s_4	561	563	543	554

3. Hungarian method

The concept of assignment problems using the Hungarian method is applied to solve a problem for our case study. The algorithm can be summarized through the following steps

Step -1 Based on data in Table (2) Convert the problem to a minimization problem in case of maximization problem by subtracting the maximum entry in the matrix from all the entries in the matrix

Departments / Students	Biology	Math	chemistry	physics
s_1	5	1	0	10
s_2	104	108	112	110
s_3	39	66	40	55
s_4	64	62	82	71

Step -2 In every row of the cost matrix, select the smallest cost items. Subtract this item from all other items of the corresponding row. Consequently, each row of the reduced cost matrix has at least one zero

Departments / Students	Biology	Math	chemistry	physics
s_1	5	1	0	10
s_2	0	4	8	6
s_3	0	27	1	16
s_4	2	0	20	9

Step -3 Select the smallest item of each column in the reduced cost matrix and subtract it from all items of the corresponding column. Consequently, every row and column of the second reduced cost matrix should have at least one zero**.**

Departments / Students	Biology	Math	chemistry	physics
s_1	5	1	0	4
s_2	0	4	8	0
s_3	0	27	1	10
s_4	2	0	20	3

Step-4 Draw lines through suitable rows and columns to cover all of the cost matrix's zero entries using the fewest amount of lines possible. An optimal solution is found when the number of lines equals the order of the matrix

Departments / Students	Biology	Math	chemistry	physics
s_1	5	1	0	4
s_2	0	4	8	0
s_3	0	27	1	10
s_4	2	0	20	3

Step-5 Start the procedure for optimal assignment. To make the assignment, first, identify the rows containing a single zero and then indicate this zero with (□). Then, in its column, mark (×) all zeros, indicating that they cannot be selected for any further assignment. Continuity in this way until you've gone through all of the rows. Carry out the same steps for the columns as well.

Departments / Students	Biology	Math	chemistry	physics
s_1	5	1	□ 0	4
s_2	×0	4	8	□ 0
s_3	□ 0	27	1	10
s_4	2	□ 0	20	3

Step-6 In each row and column of the matrix, acquire exactly one marked zero. As shown in table (3), the assignment corresponding to these highlighted zeroes will result in the optimal assignment

Table 3- Selection Procedure using the Hungarian method

Students	Departments	Comparison degree
s_1	chemistry	625
s_2	physics	515
s_3	Biology	586
s_4	Math	563

4. Alternate Method

The Alternate method is used to solve a problem for our case study. The algorithm is summering by following steps

Step-1 Consider Table (2), Make a table with two columns, one for students and the other for the department. Find the maximum degree of comparison for every row; for example, row s_1 has the maximum degree of comparison in column chemistry, therefore we write s_1 in column 1 and chemistry in column 2. Similarly, choose every row and find their maximum degree of comparison entry for the corresponding columns, as shown below.

Column1	**Column2**
s_1	chemistry
s_2	Biology
s_3	Biology
s_4	Math

Step-2 Check whether students have a unique average, and then allocate that department to the respective student. Then, for the student that has already been assigned, remove that row and its related column. Otherwise, check which rows have only one same section. Assign the section with the maximum difference degree of comparison. Delete the rows and columns that correspond to the students that have been allocated to them.

Step-3 Assign the students s_1, s_2, s_3, and s_4 to departments Biology, Math, chemistry , and physics as shown in table (4).

Table 4- Selection procedure using Alternate method

Students	**Departments**	**Comparison degree**
s_1	chemistry	625
s_2	physics	515
s_3	Biology	586
s_4	Math	563

5. The New Technique Method

The new technique method is used to solve a problem for our case study. The algorithm is summering by following steps

Step -1 Based on data in Table (2) transform the problem to a minimization problem in case of maximization problem by subtracting the maximum entry in the matrix from all the entries in the matrix

Departments / **Students**	**Biology**	**Math**	**chemistry**	**physics**
s_1	5	1	0	10
s_2	104	108	112	110
s_3	39	66	40	55
s_4	64	62	82	71

Step -2 Compute the two minimum values for each row and output the difference between them (referred to as the penalty); similarly, determine the two maximum values for each column and produce the difference between them (called the penalty).

Departments / **Students**	**Biology**	**Math**	**chemistry**	**physics**	**Penalty**
s_1	5	1	0	10	1
s_2	104	108	112	110	4
s_3	39	66	40	55	1
s_4	64	62	82	71	2
Penalty	40	42	30	39	

Step -3 Identify the row or column that is associated with the largest difference found in Step 2

Departments / **Students**	**Biology**	**Math**	**chemistry**	**physics**	**Penalty**
s_1	5	1	0	10	1
s_2	104	108	112	110	4
s_3	39	66	40	55	1
s_4	64	62	82	71	2
Penalty	40	42	30	39	

Step-4 Choose the lowest value and enter it in a designated box in the column or row that corresponding to the larger difference particular in Step 3

Departments / **Students**	**Biology**	**Math**	**chemistry**	**physics**	**Penalty**
s_1	5	1	0	10	1
s_2	104	108	112	110	4
s_3	39	66	40	55	1
s_4	64	62	82	71	2
Penalty	40	42	30	39	

Step-5 Delete both the column and row that share the cell with the lowest value, found in the previous step.

department / students	Biology	chemistry	physics
s_2	104	112	110
s_3	39	40	55
s_4	64	82	71

Step 6- Repeat Steps 2 through 5 until each indicated square in each column and row has just one value.

Departments / Students	Biology	chemistry	physics		Penalty
s_2	104	112	110	6	2
s_3	39	40	55	1	
s_4	64	82	71	7	11
Penalty	40	30	39		
		30	39		

Step-7 Assign the student's s_1, s_2, s_3, and s_4 to departments Biology, Math, chemistry and physics as shown in table (5)

Table 5- Selection procedure using the new technique

Students	Departments	Comparison degree
s_1	Math	624
s_2	chemistry	513
s_3	Biology	586
s_4	physics	554

6. Conclusion

The assignment problem (AP) is a tool used to solve problems in the real world. In organization and other applications, an assignment problem is crucial. It is the responsibility of the Department of University registration to distribute students who have completed the general registration requirements to the departments. This study aims to demonstrate the usefulness of appointment model techniques in the distribution of students to the departments of the educational institution, and to maximize the degree of comparison in optimal distribution of students. According

to the allocation students shown in the table (3), (4) and (5) we conclude that the students' assignment with respect to the Hungarian and Alternative techniques is better than the new technique, and this corresponds to the optimal distribution of students of the collage of Science based on the degree of comparison for the desired department. For example, the allocation of student s_1 in the new way by degree of comparison less than the two methods Hungarian and alternative and this is not consistent with solving the problems of appointment with an objective function of the type of maximization. The outcome indicated that the College of the Sciences one of the Universities of Iraq ought to allocate the department chemistry to the student s_1 with the degree of comparison 625, the department physics to the student s_2 with the degree of comparison 515, the department Biology to the student s_3 with the degree of comparison 586, the department math to the student s_4 with the degree of comparison 563.

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