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Optimization of Classroom Utilization in Course Scheduling Using the Hungarian Method: A Case Study at the Faculty of Science, Universitas Cokroaminoto Palopo

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Abstract

This study aims to optimize the course scheduling process at the Faculty of Science, Universitas Cokroaminoto Palopo, using the Hungarian method. The Hungarian method is an algorithm used to solve assignment problems and provides two types of solutions, namely minimization and maximization solutions. The data were analyzed using POM-QM for Windows software, which is capable of generating optimal solutions for designing effective and efficient course schedules. The results indicate that all courses can be conducted using a maximum of 5 classrooms and 2 lecture time slots. Furthermore, classroom utilization efficiency is within the range of 20% < efficiency < 55%, showing an improvement compared to the scheduling system prior to the implementation of the Hungarian method.

Keywords: Scheduling; Hungarian Method; Optimization; Assignment

1. Introduction

Scheduling is a classic problem that remains relevant to this day. Effective scheduling improves productivity and the efficient use of available resources, whether human or time [1,2]. Scheduling issues generally involve class scheduling in schools or universities, as well as employee scheduling in companies and hospitals. One of the scheduling problems encountered in higher education institutions is course scheduling. The course scheduling process is an important stage that requires proper organization in academic activities within a university [3].

Course scheduling must be properly organized; therefore, an optimization method is required to optimize classroom utilization. One way to optimize classroom utilization is by assigning courses to appropriate classrooms. The assignment of courses to classrooms also depends on the duration of each course, the number of students enrolled, and the number of lecturers teaching the course in order to avoid scheduling conflicts.

Lecture scheduling problems differ across universities, meaning that each educational institution has its own unique scheduling challenges. A similar issue occurs at the Faculty of Science, UNCP, where the lecture scheduling process is still carried out manually. As a result, the scheduling process requires considerable time and produces

less efficient outcomes. This issue is classified as an assignment problem, which is considered a special case of linear programming.

The issue of task assignment refers to the process of assigning tasks to individuals in order to minimize the costs or time required to complete those tasks [4] [5]. The problem of course scheduling can be solved using the Hungarian method.

The Hungarian method is one of the most effective and straightforward methods for solving assignment problems [6] [7] . This method was developed by a Hungarian mathematician named D. König in 1916. The Hungarian method is highly efficient in terms of its iterative process. This method is presented in the form of a rectangular matrix, where the rows represent human resources and the columns represent tasks. Therefore, to optimize the course scheduling process in this study, the Hungarian method was used to obtain accurate and efficient scheduling results [8] [9].

Previous studies have applied the Hungarian method in industrial and workforce assignment problems; however, its application to classroom allocation optimization in Indonesian higher education institutions remains limited. Therefore, this study aims to fill this gap by evaluating classroom utilization efficiency through assignment-based scheduling

2. Materials and Methods

2.1 Type of Research

The type of research used in this study is quantitative research. Quantitative research is a method used to address research questions related to numerical data. [10].

2.2 Time and Location of the Study

Data for this study was collected from the Mathematics Study Program and analyzed at the Computing Laboratory on UNCP Campus II, located at Jl. Lamaranginang, Wara Utara District, Palopo City, South Sulawesi. The study was conducted from March 2023 to April 2023.

2.3 *Data Collection Methods*

According to [11], data refers to information obtained through specific measurements, which is used as the basis for constructing logical arguments into facts, whereas facts themselves are realities whose validity has been verified through data analysis. The data used in this study is secondary data in the form of the even-semester course schedule for the Mathematics Study Program at the Faculty of Natural Sciences, UNCP. Secondary data refers to information collected from existing sources. Sources of secondary data include company records or documentation, government publications, industry analyses by the media, websites, the internet, and so on.

2.4 Analysis Phase

The steps for solving scheduling problems using the Hungarian Method [12] [13], are as follows:

1. Identify and simplify the problem into an assignment matrix.
2. Determine the minimum value in each row, then subtract that minimum value from each number in the row.
3. Determine the minimum value in each column, then subtract that minimum value from each number in the column.

Draw lines through the rows and columns containing zeros by first selecting the rows or columns with the greatest number of zeros [14] [15]. If the total number of lines

is equal to the number of rows or columns, the table is considered optimal. Otherwise, proceed to the next step.

3. Results

3.1 *Research Data*

In this study, the researcher used the course schedule for the even semester of the Mathematics Study Program, Faculty of Science, for the 2022/2023 academic year.

Table 1. Course Schedule

Day	Time	Semester	Course	Class-room
Monday	07.30-10.00	VI	Partial Differential Equations	G6
	10.00-11.40	VI	Discrete Mathematics	H2
Tuesday	07.30-10.00	IV	Basic Programming	H2
	13.00-14.00	IV	Financial Mathematics	G6
Wednesday	10.30-13.00	IV	Mathematical Statistics	G6
	13.00-14.40	IV	Management Science	G4
Friday	08.20-10.00	IV	Ring Theory	G4
	10.00-12.00	IV	Applied Statistics	G5
	13.00-15.30	IV	Fuzzy Theory	G5
	13.30-15.10	VI	Plane and Solid Geometry	H3
	15.10-17.40	VI	Data Analysis	G9
Saturday	10.00-12.30	VI	Mathematical Modeling	G4

Source: Mathematics Study Program, Faculty of Science (2023)

Based on the schedule presented in Table 1, the following data were obtained: $I = \{1, \dots, 10\}$, where I represents the set of course indices, while $J = \{1, \dots, 66\}$, represents the set of room-time pair indices, consisting of combinations of 3 days, 2 time slots, and 6 classrooms; 1 day, 4 time slots, and 6 classrooms; as well as 1 day, 1 time slot, and 6 classrooms.

Table 2. The Number of Students Enrolled in Each Course Schedule

Course	Course Participants
Partial Differential Equations	2
Discrete Mathematics	2
Basic Programming	6
Financial Mathematics	6
Mathematical Statistics	6
Management Science	6
Ring Theory	6
Applied Statistics	6
Fuzzy Theory	6
Plane and Solid Geometry	2
Data Analysis	2
Mathematical Modeling	2

Source: Mathematics Study Program, Faculty of Science (2023)

Table 3. The Capacity of Each Classroom

Classroom		Classroom Capacity
R1	H2	41
R2	H3	45
R3	G4	38
R4	G5	37
R5	G6	40
R6	G9	44

Source: Secondary Data (2023)

The first step in solving the course scheduling model aimed at maximizing classroom utilization efficiency is to input the objective function coefficient values based on Equation (5) into a Microsoft Excel worksheet. If the number of courses is not equal to the number of room-time pairs, dummy course variables or dummy room-time pair variables are added to satisfy the requirements of an assignment problem that can be solved using the Hungarian Method. This process forms an $n \, x \, n$ matrix known as the Occupation Matrix. The Occupation Matrix for the course schedule is presented in the following table:

Table 4. Occupation Matriks for Monday

room-time (j) / matkul (i)	1	2	3	4	5	6	7	8	9	10	11	12
	S1-R1	S1-R2	S1-R3	S1-R4	S1-R5	S1-R6	S2-R1	S2-R2	S2-R3	S2-R4	S2-R5	S2-R6
Persamaan Diferensial Parsial	-0.951	-0.955	-0.947	-0.945	-0.95	-0.954	0	0	0	0	0	0
Matematika Diskrit	0	0	0	0	0	0	-0.951	-0.955	-0.947	-0.945	-0.95	-0.954
MK3	0	0	0	0	0	0	0	0	0	0	0	0
MK4	0	0	0	0	0	0	0	0	0	0	0	0
MK5	0	0	0	0	0	0	0	0	0	0	0	0
MK6	0	0	0	0	0	0	0	0	0	0	0	0
MK7	0	0	0	0	0	0	0	0	0	0	0	0
MK8	0	0	0	0	0	0	0	0	0	0	0	0
MK9	0	0	0	0	0	0	0	0	0	0	0	0
MK10	0	0	0	0	0	0	0	0	0	0	0	0
MK11	0	0	0	0	0	0	0	0	0	0	0	0
MK12	0	0	0	0	0	0	0	0	0	0	0	0

Source: Processed Secondary Data (2023)

Table 5. Occupation Matriks for Tuesday

room-time (j) / matkul (i)	1	2	3	4	5	6	7	8	9	10	11	12
	S1-R1	S1-R2	S1-R3	S1-R4	S1-R5	S1-R6	S2-R1	S2-R2	S2-R3	S2-R4	S2-R5	S2-R6
Pemrorgraman Basic	-0.853	-0.866	-0.842	-0.837	-0.85	-0.86	0	0	0	0	0	0
Matematika Finansial	0	0	0	0	0	0	-0.853	-0.866	-0.842	-0.837	-0.85	-0.86
MK3	0	0	0	0	0	0	0	0	0	0	0	0
MK4	0	0	0	0	0	0	0	0	0	0	0	0
MK5	0	0	0	0	0	0	0	0	0	0	0	0
MK6	0	0	0	0	0	0	0	0	0	0	0	0
MK7	0	0	0	0	0	0	0	0	0	0	0	0
MK8	0	0	0	0	0	0	0	0	0	0	0	0
MK9	0	0	0	0	0	0	0	0	0	0	0	0
MK10	0	0	0	0	0	0	0	0	0	0	0	0
MK11	0	0	0	0	0	0	0	0	0	0	0	0
MK12	0	0	0	0	0	0	0	0	0	0	0	0

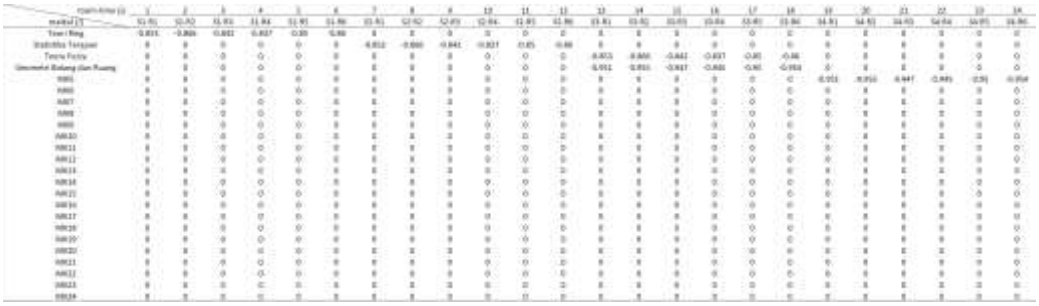
Source: Processed Secondary Data (2023)

Table 6. Occupation Matriks for Wednesday

room-time (j) / matkul (i)	1	2	3	4	5	6	7	8	9	10	11	12
	S1-R1	S1-R2	S1-R3	S1-R4	S1-R5	S1-R6	S2-R1	S2-R2	S2-R3	S2-R4	S2-R5	S2-R6
Statistika Matematika	-0.853	-0.866	-0.842	-0.837	-0.85	-0.86	0	0	0	0	0	0
Manejemen Sains	0	0	0	0	0	0	-0.853	-0.866	-0.842	-0.837	-0.85	-0.86
MK3	0	0	0	0	0	0	0	0	0	0	0	0
MK4	0	0	0	0	0	0	0	0	0	0	0	0
MK5	0	0	0	0	0	0	0	0	0	0	0	0
MK6	0	0	0	0	0	0	0	0	0	0	0	0
MK7	0	0	0	0	0	0	0	0	0	0	0	0
MK8	0	0	0	0	0	0	0	0	0	0	0	0
MK9	0	0	0	0	0	0	0	0	0	0	0	0
MK10	0	0	0	0	0	0	0	0	0	0	0	0
MK11	0	0	0	0	0	0	0	0	0	0	0	0
MK12	0	0	0	0	0	0	0	0	0	0	0	0

Source: Processed Secondary Data (2023)

Table 7. Occupation Matriks for Friday



Source: Processed Secondary Data (2023)

Table 8. Occupation Matrix for Saturday

Room-Time (j) / **Course (i)**	**1** **S1-R1**	**2** **S1-R2**	**3** **S1-R3**	**4** **S1-R4**	**5** **S1-R5**	**6** **S1-R6**
Mathematical Modeling	-0.951	-0.955	-0.947	-0.945	-0.95	-0.954
MK2	0	0	0	0	0	0
MK3	0	0	0	0	0	0
MK4	0	0	0	0	0	0
MK5	0	0	0	0	0	0
MK6	0	0	0	0	0	0

Source: Processed Secondary Data (2023)

Based on the Occupation Matrix presented above, the data were imported into QM for Windows to obtain a course schedule that maximizes classroom utilization. The model was then solved using the Hungarian Method with the assistance of QM for Windows software, as shown in the following table.

Table 9. Optimized Monday Schedule Results

Course	***Room-Time***
Partial Differential Equations	S2-R1
Discrete Mathematics	S1-R1
MK3	S1-R2
MK4	S1-R3

MK5	S1-R4
MK6	S1-R5
MK7	S1-R6
MK8	S2-R2
MK9	S2-R3
MK10	S2-R4
MK11	S2-R5
MK12	S2-R6

Source: Processed Secondary Data (2023)

Table 10. Optimized Tuesday Schedule Results

Course	***Room-Time***
Basic Programming	S2-R1
Financial Mathematics	S1-R1
MK3	S1-R2
MK4	S1-R3
MK5	S1-R4
MK6	S1-R5
MK7	S1-R6
MK8	S2-R2
MK9	S2-R3
MK10	S2-R4
MK11	S2-R5
MK12	S2-R6

Source: Processed Secondary Data (2023)

Table 11. Optimized Wednesday Schedule Results

Course	***Room-Time***
Mathematical Statistics	S2-R1
Management Science	S1-R1
MK3	S1-R2
MK4	S1-R3
MK5	S1-R4
MK6	S1-R5
MK7	S1-R6
MK8	S2-R2
MK9	S2-R3
MK10	S2-R4
MK11	S2-R5
MK12	S2-R6

Source: Processed Secondary Data (2023)

Table 12. Optimized Friday Schedule Results

Course	***Room-Time***
Ring Theory	S2-R1
Applied Statistics	S1-R1
Fuzzy Theory	S1-R2
Plane and Solid Geometry	S1-R3
Data Analysis	S1-R4
MK6	S1-R5
MK7	S1-R6
MK8	S2-R2
MK9	S2-R3
MK10	S2-R4
MK11	S2-R5
MK12	S2-R6
MK13	S3-R1
MK14	S3-R2
MK15	S3-R3
MK16	S3-R4
MK17	S3-R5
MK18	S3-R6
MK19	S4-R1
MK20	S4-R2
MK21	S4-R3
MK22	S3-R4
MK23	S4-R5
MK24	S4-R6

Source: Processed Secondary Data (2023)

Table 13. Optimized Saturday Schedule Results

Course	***Room-Time***
Mathematical Modeling	S1-R1
MK2	S1-R2
MK3	S1-R3
MK4	S1-R4
MK5	S1-R5
MK6	S1-R6

Source: Processed Secondary Data (2023)

Based on Tables 9, 10, 11, 12, and 13, the results of processing the Occupation Matrix using QM for Windows for Monday show that Partial Differential Equations is optimally scheduled in the second time slot of the first classroom, while Discrete Mathematics is optimally scheduled in the first time slot of the first classroom. The

Occupation Matrix results for the other days are interpreted in the same manner. Accordingly, the final schedule obtained is presented in Table 14.

Table 14. Course Schedule After Applying the Hungarian Method to Maximize Classroom Utilization Efficiency

Day	Time	Semester	Course	Classroom
Monday	07.30-09.10	VI	Discrete Mathematics	H2
	09.10-11.40	VI	Partial Differential Equations	H2
Tuesday	07.30-09.10	IV	Financial Mathematics	H2
	13.00-15.30	IV	Basic Programming	H2
Wednesday	10.30-12.10	IV	Management Science	H2
	12.10-14.40	IV	Mathematical Statistics	H2
Friday	08.20-10.50	IV	Applied Statistics	H2
	08.20-10.50	IV	Fuzzy Theory	H3
	08.20-10.00	IV	Plane and Solid Geometry	G4
	08.20-10.00	VI	Data Analysis	G5
	10.50-12.30	VI	Ring Theory	H2
Saturday	10.00-12.30	VI	Mathematical Modeling	H2

Source: Processed Secondary Data (2023)

3.2 Classroom Utilization

Based on the obtained scheduling results, classroom utilization can be analyzed using the following calculation:

$$Classroom\ Utilization(j) = \frac{Classroom\ usage\ (j)(credits)}{Total\ allowed\ credits\ on\ day\ k} 100 \qquad (1)$$

Based on Equation (1), the average classroom space utilization for each day was obtained, as presented in Table 15.

Table 15. *Classroom Utilization*

Classroom	Average Schedule Utilization Before Optimization	Average Schedule Utilization After Optimization
H2	25%	55%
H3	20%	30%
G4	31,7%	20%
G5	30%	20%

Sumber: Processed Secondary Data (2023)

4. Discussion

To obtain an optimal course schedule using the Hungarian method, the process begins by constructing an assignment table in which course types are represented as rows, while time slots and classrooms are represented as columns. A total of 12 course

schedules were arranged, involving 5 classrooms with different time slots for lectures conducted over five days a week, namely Monday, Tuesday, Wednesday, Friday, and Saturday. Prior to applying the Hungarian method, the scheduling process resulted in a total of 11 time slots being utilized within a week. However, after applying the Hungarian method, the total number of utilized time slots was reduced to 9 per week.

Based on the schedule presented in Table 13, all courses can be conducted using only 4 classrooms and 2 lecture time slots. Table 14 shows that the highest utilization in the existing schedule was recorded for classroom G4, whereas the highest utilization in the optimized schedule was observed for classroom H2. Furthermore, Table 14 indicates that the utilization rate of each classroom is greater than 20% and less than 55%. Therefore, it can be concluded that the efficiency of classroom utilization in the course scheduling system of the Mathematics Study Program, Faculty of Science, Universitas Cokroaminoto Palopo, falls within the range of 20% < efficiency < 55%.

The findings of this study have important implications for university scheduling management. By reducing the number of required classrooms and lecture time slots while maintaining adequate classroom utilization, the proposed scheduling approach enables academic administrators to allocate teaching facilities more efficiently. The unused classrooms can be reassigned for laboratory activities, student events, examinations, or maintenance without disrupting the regular teaching schedule. Furthermore, a more compact timetable reduces scheduling conflicts, simplifies coordination among departments, and decreases the administrative workload associated with manual scheduling revisions.

From a strategic perspective, implementing the Hungarian method can support data-driven academic planning and improve institutional resource management. Universities can utilize this optimization approach to accommodate increasing student enrollment without immediately expanding physical infrastructure. In addition, the method provides a transparent and systematic framework for scheduling decisions, making it easier to evaluate alternative scheduling scenarios and improve operational efficiency in future academic semesters. Nevertheless, the current study focuses primarily on classroom assignment and time-slot optimization. Future research should incorporate additional constraints, such as lecturer preferences, student course combinations, classroom equipment requirements, and multi-objective optimization, to produce scheduling solutions that are more applicable to complex university environments.

5. Conclusions

Based on the results of the discussion, it can be concluded that there are differences between the course schedule arranged by the Mathematics Study Program, Faculty of Science, and the course schedule developed using the Hungarian method. The schedule generated using the Hungarian method demonstrates more efficient classroom usage in terms of the number of classrooms utilized and higher classroom utilization rates. In addition, there are course schedules with the same classroom allocation but different time slot placements, as well as schedules with the same time slots but different classroom allocations.

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