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GRAPH COLORING IMPLEMENTATION USING WELCH POWELL ALGORITHM IN LECTURE SCHEDULING DESIGN FOR MATHMATICS DEPARTMENT

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ABSTRACT

Designing the scheduling of lecture rosters is one of the common problems faced by all universities. The problem that often occurs as a conflict in the lecture schedule. Lecturers who teach courses, students cannot take certain courses because the lecture schedule they are taking conflicts with other lecture schedules. The main problem in this research is the design of lecture schedules which always conflict due to room availability and lecturer teaching hours. As a result, lecture scheduling becomes more complicated. The case study used is the scheduling of lectures for the Mathematics Department, Faculty of Science and Technology, UIN Sumatera Utara, Medan in the even semester of the 2022/2023 academic year. In this research, a bipartition graph will be formed based on the variables used, namely determining the variable index used in the course, teaching lecturer, teaching time, entry time, exit time, classroom, number of credits, semester and color. After that, the Welch Powell Algorithm will be used to solve the scheduling problem of a bipartition graph which is formed by creating nodes, membership matrix and the final result is a tabulation of the colored bipartition graph as the output of the scheduling. This algorithm also uses MATLAB software. From the results obtained, the algorithm provides an effective digital solution in designing lecture roster scheduling which is still done manually. This will help the mathematics department in overcoming the problems mentioned above. The research results will be explained detail in the results and discussion section.

Keywords: Scheduling, Lecture Rosters, Bipartition Graph, Coloring Graphs, Welch Powell Algorithm

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PRELIMINARY

In everyday life, we often face problems that require careful planning. An example is the scheduling problem, if the daily routine is not organized well and carefully, chaos will occur (Yu, 2021). Scheduling is very complicated because there are several limiting factors such as time, space and location that need to be planned (Lee & Loong, 2019).

Scheduling is not just an individual activity, but is an urgent aspect in the academic world. For example, a course scheduling roster. Basically, education and learning such as schools or universities will run effectively if the schedule can meet students' needs

(Gunawan et al., 2007). Scheduling activities that take place at a university are semester by semester, manual and complex, with many factors that must be considered and the scheduling process also takes a long time, class space, number of teachers teaching, student needs, and faculty supporting the courses are also taken into consideration in the plan (Chen et al., 2020).

It is hoped that proper schedule distribution can provide solutions to aspects that influence the lecture schedule (Franky et al., 2022). The schedule is formed as best as possible so that no lecturer's lectures conflict when giving lectures on the same day and time, however, not all lecture schedules have the same problem as the university's planned needs (Chen et al., 2022).

In Department of Mathematics, Faculty of Science and Technology, UIN Sumatera Utara Medan, the problem of scheduling design moves from the odd semester lectures for the 2022-2023 academic year, in the odd semester there are still many obstacles in determining the distribution of lectures. Aspects that influence lectures in Department of Mathematics such as the availability of lecture rooms, the availability of lecturers, the availability of course instructors. Therefore, each learning instructor is burdened with many classes at each semester level. This causes the Department of Mathematics to often have schedule conflicts for both students taking courses and lecturers who teach, resulting in many classrooms and faculty lecture hours being shifted, which ultimately causes lecturers to have to arrange lecture schedules with their students to avoid clashes with students. other lectures.

For the problems above, we need a technology that can distribute lecture plans efficiently to overcome schedule pile-ups. In applying mathematical concepts, graph theory plays an important role in overcoming schedule build-up, such as using coloring graph implementation. The specialty of graph theory is the convenience of the objects studied, because they can be represented as vertices and edges (Stanković et al., 2019). There are many methods that can overcome scheduling problems, including the use of coloring graphs. The main principle of graph coloring is to make the lecture schedule as effective as possible, without any bumped-schedule between one schedule and another.

Coloring graphs are a simple method for scheduling systems because they include graph concepts in their work (Hazizah et al., 2023). Coloring graphs are partitioned into three parts, namely coloring edges, coloring points, and coloring regions. Coloring the edges of a graph is done if two edges meet at the same point with different colors (De, 2022). Meanwhile, coloring the points of a graph is directly connected to two points with different colors.

Algorithms are needed to coloring graphs, including the Welch-Powell algorithm (Saluky, 2022). It is possible to color graphs efficiently by using this algorithm to color points according to their levels. This algorithm does not always provide the minimum constraints needed to color a graph, but it is very useful when coloring (Silitonga & Mulyono, 2023). This algorithm works quite well when planning scheduling with problems that are large enough so that this algorithm can be used to create schedules that meet various desired conditions (Perera & Lanel, 2016).

Based on the problem above, this research uses a colored graph which is formed based on a bipartition graph. After the bipartition graph is formed, it will be solved using the Welch Powell algorithm. The main problem moves from the odd semester 2022-2023 academic year. The implementation of the Welch Powell algorithm will be carried out especially in the even semester of the 2022/2023 academic year, especially in the second semester because in this semester there are quite complicated problems which are mapped into the following variables, including courses, teaching lecturers, teaching time, entry hours, hours exit, class room, number of credits, semester and color. These variables can influence course scheduling planning where lecture conflicts will often occur in the lecture process, especially for mathematics department.

Literature Review

Graph Theory

The definition of a graph is given by the pair of sets (V, E), which are written as $G = (V, E)$, V is the set of non-empty vertices (nodes), and E is the set of sides (edges or arcs) linking a pair of nodes (Samarasekara, 2018) and (Erciyes, 2021). There are no explicit guidelines for geometry in the graph's display, such as where to place the vertices and sections (Diestel, 2017). We can observe how the same graph is presented in a different graph $G = (V, E)$ (Cipta, 2020):

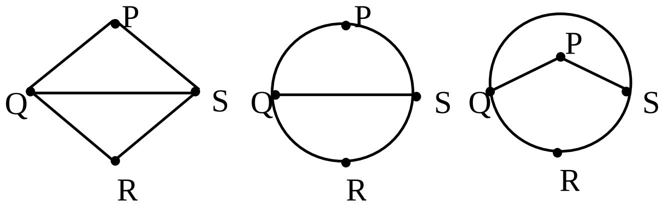

Figure 1. Examples of Graph

The set V of vertices and the set E of edges form a G-directional graph in which the ribs $e \in E$ link the pairs of consecutive vertices. And the G-undirectional graph has the property that each edge corresponds to a pair of non-consecutive vertices in the set *V* of the vertices and the set of edges $e \in E$ in the set *E* of the edges.

Coloring Graph

Vertex coloring is an activity of coloring each graph vertex so that two neighboring vertices have different colors (Sunanto et al., 2022). Notation for coloring nodes is usually in the form of numbers 1,2,3,... or letters $(\alpha, \beta, \gamma, ...)$. If a graph has no loops then the graph vertices can be directly colored (*k*-colourable) with $k-1$ which varies between nodes that are close to each other. Meanwhile, a graph that is *k*-colourable but is not $k-1$ is called a chromatic number (Yadav, 2023).

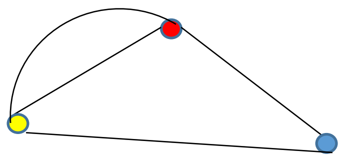

Figure 2. Coloring of edge

Graph Chromatic Numbers

The main challenge in coloring graph vertices is ensuring that no two neighboring vertices share the same color. Utilizing the fewest colors feasible is directly tied to this coloring issue. (Balakrishnan, 2012). The chromatic number of the graph is the smallest set of colors that can be used to color every vertex *G*, and symbolized by $\chi(G)$. The following are characteristics of the minimal number of colors required for node coloring, or the chromatic number (Otala et al., 2021) and (Karin, 2021):

1. $\chi(G)=1$ if and only if *G* is an empty graph. This is because all the nodes are not connected, so to color all the nodes you only need one color.Graf lengkap memiliki K_n memiliki $\chi(G)=n$.
2. Circle graph C_n have $\chi(G)=2$ if *n* is even and $\chi(G)=3$ if *n* is odd.
3. Bipartit graph $K_{m,n}$ can always be colored with 2 colors.
4. Graphs in the form of trees can always be colored with 2 colors.

Coloring Graph Algorithm

The colored graph algorithm used in this research is the Welch-Powell Algorithm (Fransisca & Kurniawan, 2020). This approach involves coloring vertices in a graph according to the highest degree vertex that was sorted first. The Greddy algorithm includes the Welch Powell algorithm (Lewis, 2021) and (Hazizah et al., 2023), when the Kruskal's algorithm and the Prims algorithm are available in addition to the Welch Powell algorithm (Cipta & Widyasari, 2020). The steps for coloring using the Welch Powell algorithm are as follows (Ganguli & Roy, 2017) and (Abdullah et al., 2019):

1. Labeling the vertex with their degrees. Vertex labels with $v_1, v_2, ..., v_n$ so that $v_1 > v_2 > ..., v_n$.
2. First color the uncolored dots from the uncolored dots adjacent to that dot. Assign the unused color to the first uncolored dot in the dot list. Do this for all the points in the list in order, giving this new color to every point that is not adjacent to every other point that has already been colored..
3. The graph has been colored. If some of the dots are not colored yet, back to step 2.
4. Done, the graph coloring has been carried out.

METHODS

This study was carried out at the Department of Mathmatics, Faculty of Science and Technology, Universitas Islam Negeri Sumatera Utara, Deli Serdang Regency. Time for this research is planned from November 2022 until completion. Secondary data was obtained from second semester at department of mathematics in the form of lecturer data, number of classes, lecturer teaching times and days as well as distribution of courses offered in the even semester of the 2022/2023 academic year.

The flow of the research carried out is described below:

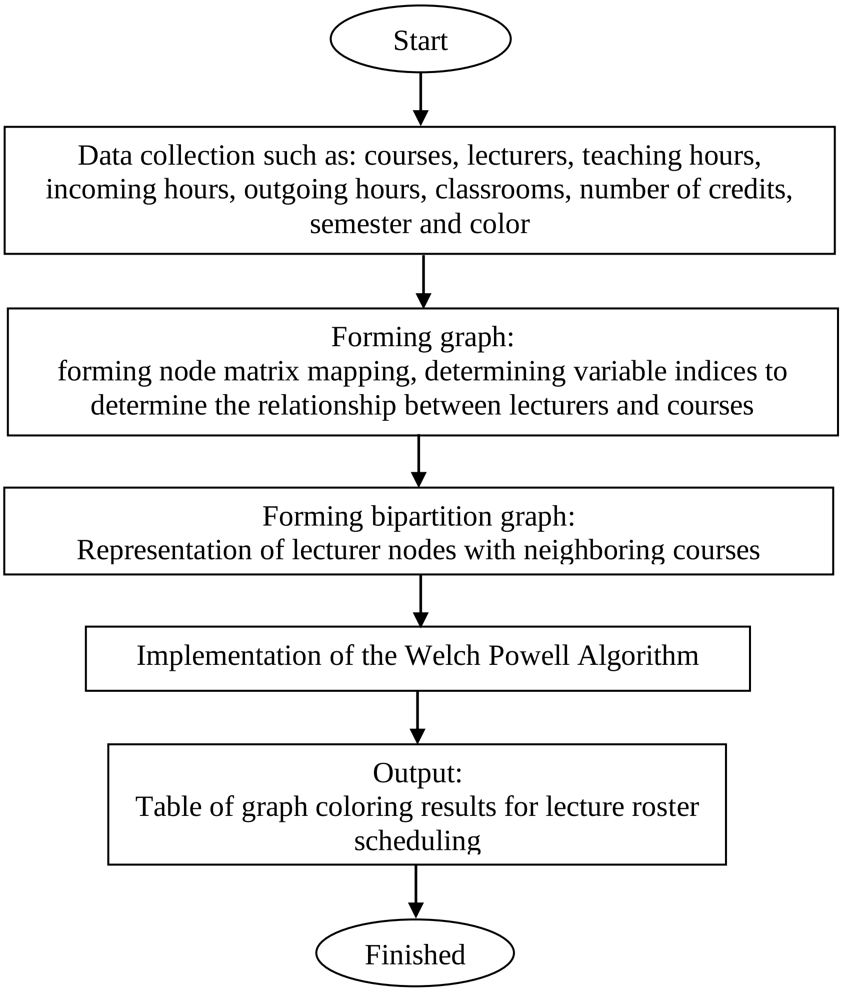

Figure 3. Flowchart Design

RESULT AND DISCUSSION

Bipartition Graph Forming

A bipartition graph is formed through the process:

1. Create a neighbor matrix

Let graph $G = (V, E)$ is a graph with a set of vertices from the set of all courses in even semester 2022/2023 academic years of Mathematics Department, while the edge set is all lecturers who teach TA even semester courses in 2022/2023 academic years or all Mathematics Department students who take lectures in the even semester in 2022/2023 academic. In this case, an adjacency matrix of G will be formed (Michael, 2022):

$$A(G) = \left[a_{ij} \right] \quad (1)$$

where:

$$a_{i,j} = \begin{cases} 1, \text{ if vertex } v_i \text{ dan vertex } v_j \text{ neighbor} \\ 0, \text{if vertex } v_i \text{ dan if vertex } v_j \text{ non-neighbor} \end{cases} \tag{2}$$

Vertex v_i is said to be adjacent to vertex v_j if there is a lecturer who teaches course *i* who also teaches course *j*, or a student who takes course *i* also takes course *j*. This means that courses *i* and *j* cannot be implemented at the same time, because it will result in clashes between both the lecturer teaching and the students taking the course. On the other hand, point v_i is said to not be adjacent to vertex v_j if the lecturer who teaches course *i* does not teach course *j* and the students who take course *i* do not take course *j*. This means that courses *i* and *j* can be carried out at the same time, because it will not result in clashes between the lecturer who teaches and the students who take the course.

2. Determine the chromatic number of the graph

The minimum number of colors that can be used to color all vertices is called the chromatic number of the graph *G* which is symbolized (Yusheng, 2022):

$$\chi(G) \tag{3}$$

The graph chromatic number in equation (3) is used in graph vertex coloring, which is to color all vertices in the graph so that no adjacent vertices have the same color.

3. Forming *k*-colorable

Definition 1. *k-colorable in a graph G = (V, E) is the number of k-colors assigned to each edge or vertex in G = (V, E) so that no two adjacent edges or vertices have the same color* (Lewis, 2021). Below will be illustrate the combinatoric polynomial of *k*-colorable on a graph *G = (V, E)*.

$$x_i^k - 1 = 0, \text{ for each vertex } i \in V(G) \tag{4}$$

$$x_i^{k-1} + x_i^{k-2} x_j + \ldots + x_j^{k-1} = 0, \text{ for each vertex } \{i, j\} \in E(G) \tag{5}$$

4. Solving coloring graph using the Welch-Powell Algorithm

As explained in the theory section, the Welch-Powell Algorithm is an algorithm that can solve graph coloring problems. In this research, this algorithm is used to solve the lecture roster scheduling problem. This algorithm process is carried out manually based on the procedural steps in the algorithm itself (see the theory section), after which the help of MATLAB software will be used in forming the node matrix mapping, determining the index of the variables used (courses, teaching lecturers, teaching time, incoming hours, outgoing hours , class room, number of credits, semester and color), determining the relationship between lecturers and courses, forming a bipartition graph in the representation of lecturer nodes with neighboring courses and the final result is determining the graph coloring results for the lecture schedule. All work processes will be described in the results and discussion of this research.

Table 1. List of mathematics course and lectures in second semester

No	Course	Lectures	Code
1	Kewarganegaraan A / Civics A	Fitri Amelia Ritonga, M.Pd	FAR
2	Kewarganegaraan B / Civics B	Fitri Amelia Ritonga, M.Pd	FAR
3	Kewarganegaraan C / Civics C	Fitri Amelia Ritonga, M.Pd	FAR
4	Fiqh A / Islamic Law A	Sri Ulfa Rahayu, M.Th	SUR
5	Fiqh B / Islamic Law B	Sri Ulfa Rahayu, M.Th	SUR
6	Fiqh C / Islamic Law C	Sri Ulfa Rahayu, M.Th	SUR
7	Etika Akademik A / Academic Ethics A	Dr. Rina Filia Sari, M.Si	RFS
8	Etika Akademik B / Academic Ethics B	Dr. Rina Filia Sari, M.Si	RFS
9	Etika Akademik C / Academic Ethics C	Dr. Rina Filia Sari, M.Si	RFS
10	Filsafat Ilmu A / Science Phylosophy A	Dr. Sajaratud Dur, M.T	SJD
11	Filsafat Ilmu B / Science Phylosophy B	Dr. Sajaratud Dur, M.T	SJD
12	Filsafat Ilmu C / Science Phylosophy C	Dr. Sajaratud Dur, M.T	SJD
13	Bahasa Indonesia A / Indonesian Language A	Dila Handayani, M.Si	DLH
14	Bahasa Indonesia B / Indonesian Language B	Dila Handayani, M.Si	DLH
15	Bahasa Indonesia C / Indonesian Language C	Dila Handayani, M.Si	DLH
16	Kalkulus Integral A / Integral Calculus A	Dr. Hendra Cipta, M.Si	HCP
17	Kalkulus Integral B / Integral Calculus B	Dr. Hendra Cipta, M.Si	HCP
18	Kalkulus Integral C / Integral Calculus C	Dr. Fibri Rakhmawati, M.Si	FIB
19	Matematika Diskrit A / Discrete Mathematics A	Dr. Rina Filia Sari, M.Si	RFS
20	Matematika Diskrit B / Discrete Mathematics B	Dr. Rina Filia Sari, M.Si	RFS
21	Matematika Diskrit C / Discrete Mathematics C	Dr. Rina Filia Sari, M.Si	RFS
22	Metode Statistika A / Statistical Methods A	Dr. Ismail Husein, M.Si	IHN
23	Metode Statistika B / Statistical Methods B	Dr. Ismail Husein, M.Si	IHN
24	Metode Statistika C / Statistical Methods C	Dr. Ismail Husein, M.Si	IHN
25	Pengantar Ilmu Komputer A / Introduction to Computer Science A	Dr. Ismail Husein, M.Si	IHN
26	Pengantar Ilmu Komputer B / Introduction to Computer Science B	Dr. Ismail Husein, M.Si	IHN
27	Pengantar Ilmu Komputer C / Introduction to Computer Science C	Dr. Ismail Husein, M.Si	IHN

The process of bonding between course and lecturers in the department of mathmatics will be carried out by applying a mark. The explanation for determining marks is carried out with the statement that lecturers who teach courses in accordance with their field will be given a score of “1” (one), while lecturers who do not have linearity in the field of competence with the course will be given a score of “0” (zero). The application of the commands used in establishing lecturer linearity with subjects can be done using following MATLAB coding command formulation:

```
% Fill the node matrix with 1 if there is a relationship between courses and lecturers
for i = 1:size(data, 1)
    courses_idx = find(ismember(courses_unique, data{i, 1}));
    lecturer_idx = find(ismember(lecturer_unique, data{i, 2}));
    matrix_node(course_idx, lecturer_idx) = 1;
end
```

Tabel 2. Node Matrix for Lecturer and Course

Course / Lectures	Dila Handayani, M.Si	Dr. Fibri Rakhma, M.Si	Dr. Hendra Cipta, M.Si	Dr. Ismail Husein, M.Si	Dr. Rina Filia, M.Si	Dr. Sajaratud Dur, M.T	Fitri Amelia Ritonga, M.Pd	Sri Ulfa Rahayu, M.Th
Indonesian Language	1	0	0	0	0	0	0	0
Academic Ethics	0	0	0	0	1	0	0	0
Science Phylosophy	0	0	0	0	0	1	0	0
Islamic Law	0	0	0	0	0	0	0	1
Integral Calculus	0	1	1	0	0	0	0	0
Civics	0	0	0	0	0	0	1	0
Discrete Mathematics	0	0	0	0	1	0	0	0
Statistical Methods	0	0	0	1	0	0	0	0
Introduction to Computer Science	0	0	0	1	0	0	0	0

So that, if look at the node relationship between the lecturer and the course, it will form a node relationship as shown in figure 4 below.

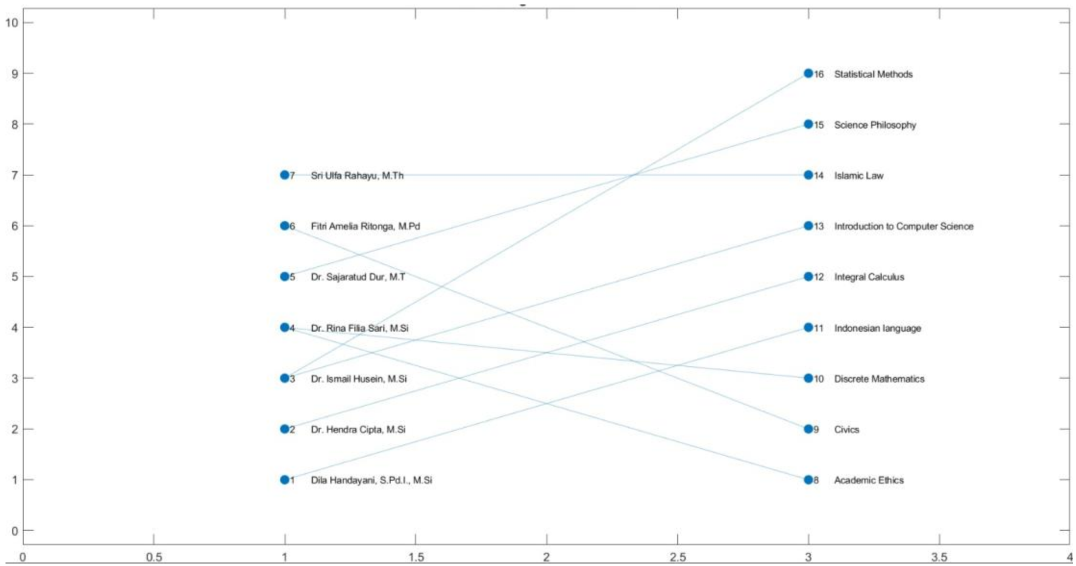

Figure 4. Relationship Between Lecturer Nodes and Course

Coloring Lecture Schedules Using the Welch-Powell Algorithm

In the process of coloring graphs using Welch Powell Algorithm, there are several adjustments, including the ordering of learning operational days and lecture start times for each session. Some of these changes were intended to help users recognize schedules more easily and prevent problems when obtaining information about the planned lecture schedule. In addition, the adjustment includes an organized and systematic way of presenting the data so that the results of testing graph coloring can be used to spot schedule problems and schedules that cross over. This may happen in every lecture schedule each semester, so that it can increase aspects of complexity in preparing lecture schedules or improve schedules due to overlapping factors between courses and lecturers who teach courses.

The procedure for coloring the lecture schedule table 2 using Welch Powell Algorithm can be modeled with the MATLAB coding which can be seen:

```
coloring = struct();
colors = [
    [1, 0, 0]; % Red
    [0, 0, 1]; % Blue
    [0, 1, 0]; % Green
.................................................................
];
color = 1;
for i = 1:length(lecturer_sequence)
    lecturer = lecturer_sequence {i, 1};
    field_name = matlab.lang.makeValidName(dosen);
    coloring.(field_name) = color;
    colors = color + 1;
    if colors > size(colors, 1)
       colors = 1;
    end
end
```

Listing code begins with a code `coloring = struct();`, this process describes the process of providing an empty matrix media which will become a container for placing lecturer data which will be colored using the Welch Powell algorithm. The coloring concept will use a series of color codes that are generated with color data originating from a combination of the main colors red, green and blue. So various types of colors will be created that can be used to color the list of lecturers who teach courses through codes `colors = []`.

Results of The Coloring Lecture Schedule for Second Semester in Mathmatics Department

The relationship between lecturer and course nodes will be created in a bipartition graph. In this case, the bipartition graph will provide a more accurate possible pair in determining the relationship between the lecturer who teaches and the course taught. This is contained in figure 5.

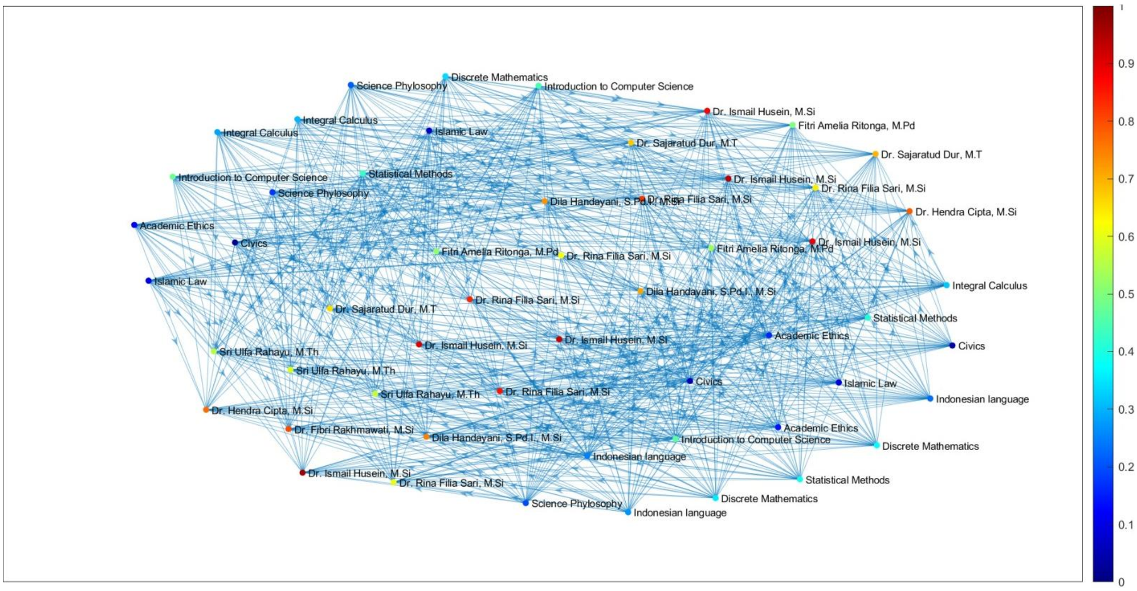

Figure 5. Representation of teaching lecturer nodes and neighboring courses

After that, the results of the modeling carried out on the second semester of lecture schedule in department of mathmatics had the availability of eight lecturers with a course distribution of nine courses. The relationship between courses and lecturers can be seen in table 3.

Table 3. Relationship Courses and Second Semester in Mathematics Department

Course / Lectures	Indonesian Language	Academic Ethics	Science Phylosophy	Islamic Law	Integral Calculus	Civics	Discrete Mathmatics	Statistical Methods	Introduction to Computer Science
Dila Handayani, S.Pd.I., M.Si	1	0	0	0	0	0	0	0	0
Dr. Fibri Rakhmawati, M.Si	0	0	0	0	1	0	0	0	0
Dr. Hendra Cipta, M.Si	0	0	0	0	1	0	0	0	0
Dr. Ismail Husein, M.Si	0	0	0	0	0	0	0	1	1
Dr. Rina Filia Sari, M.Si	0	1	0	0	0	0	1	0	0
Dr. Sajaratud Dur, M.T	0	0	1	0	0	0	0	0	0
Fitri Amelia Ritonga, M.Pd	0	0	0	0	0	1	0	0	0
Sri Ulfa Rahayu, M.Th	0	0	0	1	0	0	0	0	0

In the relationship between courses and lecturers, one lecturer has the possibility of teaching several courses, so that the coloring results of table 3 using the Welch Powell algorithm have a coloring orientation based on the name of the lecturer teaching the course. The results of table 3 coloring in the department of mathmatics in the second semester can be seen in figure 6.

Courses	Lecturer Name	Days	Entry Time	Out Time	Room Class	Credits	Semester	Color
Civics A	Fitri Amelia Ritonga, M.Pd	Monday	08:00	09:30	FST 11	2	2	
Science Phylosophy A	Dr. Sajaratud Dur, M.T	Monday	08:00	09:30	FST 6	2	2	
Civics B	Fitri Amelia Ritonga, M.Pd	Monday	09:30	11:00	FST 11	2	2	
Science Phylosophy B	Dr. Sajaratud Dur, M.T	Monday	09:30	11:00	FST 6	2	2	
Civics C	Fitri Amelia Ritonga, M.Pd	Monday	11:00	12:30	FST 11	2	2	
Science Phylosophy C	Dr. Sajaratud Dur, M.T	Monday	14:00	15:30	FST 6	2	2	
Academic Ethics A	Dr. Rina Filia Sari, M.Si	Tuesday	08:00	09:30	FST 19	2	2	
Integral Calculus A	Dr. Hendra Cipta, M.Si	Tuesday	08:00	10:15	FST 11	3	2	
Academic Ethics B	Dr. Rina Filia Sari, M.Si	Tuesday	09:30	11:00	FST 19	2	2	
Integral Calculus B	Dr. Hendra Cipta, M.Si	Tuesday	10:15	12:30	FST 11	3	2	
Academic Ethics C	Dr. Rina Filia Sari, M.Si	Tuesday	11:00	12:30	FST 19	2	2	
Introduction to Computer Science A	Dr. Ismail Husein, M.Si	Tuesday	13:15	14:45	FST 19	2	2	
Islamic Law A	Sri Ulfa Rahayu, M.Th	Tuesday	14:00	15:30	FST 6	2	2	
Introduction to Computer Science B	Dr. Ismail Husein, M.Si	Tuesday	14:45	16:00	FST 19	2	2	
Indonesian Language A	Dila Handayani, S.Pd.I., M.Si	Wednesday	08:00	09:30	FST 11	2	2	
Indonesian Language B	Dila Handayani, S.Pd.I., M.Si	Wednesday	09:30	11:00	FST 11	2	2	
Indonesian Language C	Dila Handayani, S.Pd.I., M.Si	Wednesday	11.00	12:30	FST 11	2	2	
Introduction to Computer Science C	Dr. Ismail Husein, M.Si	Wednesday	13:15	14:45	FST 19	2	2	
Integral Calculus C	Dr. Fibri Rakhmawati, M.Si	Thursday	08:00	10:15	FST 12	3	2	
Statistical Methods A	Dr. Ismail Husein, M.Si	Thursday	08:00	10:15	FST 11	3	2	
Islamic Law B	Sri Ulfa Rahayu, M.Th	Thursday	08:45	10:15	FST 6	2	2	
Statistical Methods B	Dr. Ismail Husein, M.Si	Thursday	10:15	12:30	FST 11	3	2	
Islamic Law C	Sri Ulfa Rahayu, M.Th	Thursday	11:00	12:30	FST 6	2	2	
Statistical Methods C	Dr. Ismail Husein, M.Si	Thursday	13:15	15:30	FST 11	3	2	
Discrete Mathmatics A	Dr. Rina Filia Sari, M.Si	Friday	07:45	10:00	FST 11	3	2	
Discrete Mathmatics B	Dr. Rina Filia Sari, M.Si	Friday	10:00	12:15	FST 11	3	2	
Discrete Mathmatics C	Dr. Rina Filia Sari, M.Si	Friday	14:00	16:15	FST 11	3	2	

Figure 6. Graph Coloring Results for Lecture Schedules Using Welch Powell Algorithm in Second Semester

Based on Figure 6 above, it can be seen that each teaching lecturer has different colors based on the type of course being taught, day, starting and leaving times for the lecturer teaching, classroom and number of credits. This color difference means that each lecturer can only teach courses and use classes according to his color choice, and cannot use the same color as other lecturers. Because this colored graph basically gives at least one color to each lecturer so that there are no clashes between the lecturer teaching the course and the other lecturers. So that with the minimum color given, each lecturer who teaches under the given conditions (type of course taught, day, time of entry and exit of the lecturer who teaches, class room and number of credits) is more efficient in organizing the lecture process.

In the process of coloring graphs using Welch Powell algorithm, department of mathematics makes several adjustments and anticipation steps to the lecture process, including the ordering of operational learning days and lecture start times for each session, both between the lecturer and the students being taught, as well as adjusting classes and lecture hours. can get messy. Some of these adjustments were made to make it easier for every user, both lecturers and students, to identify the schedule regularly and avoid errors in receiving information regarding the lecture schedule that will be held. Apart from that, the adjustment also has a structured and systematic representation of data presentation, so that testing graph coloring results can identify schedule errors, schedules that overlap with each other. This may happen when preparing the lecture schedule every semester, so that it can increase aspects of complexity in preparing the lecture schedule or improving the schedule due to overlapping factors between courses and lecturers who teach courses. An illustration of the results of graph coloring using Welch Powell can be seen in Figure 6 above.

CONCLUSION

Based on the research results, several conclusions were obtained: (1) A bipartition graphs were produced by forming an adjacency matrix, determining the chromatic number of the graph, forming *k*-colorable. So the formation of this bipartition graph is important in determining the relationship with all the variables studied. (2) The Welch Powell algorithm has been successfully applied to solve the problem of scheduling the list of lecturers' names in the mathematics department, especially in the even semester of the 2022/2023 academic year based on graph bipartition formed. The way the Welch Powell algorithm works uses the help of MATLAB software with coding made according to the needs of the problem. (3) Welch Powell algorithm is able to produce a schedule that does not conflict, so this algorithm can help make lecture schedules within the limits of making existing schedules, testing the algorithm results in graph coloring can also identify schedule conflict, schedules that overlap with each other. For further research, it is best to add other variables as a follow-up problem, you can also use other algorithms or methods, for example the tabu search algorithm in the same problem as this research, you can also use other software besides MATLAB software such C++ and others.

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