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# Bibliometric Analysis of University Timetabling Using Publish and Perish

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**ABSTRACT**
The University Course Timetabling Problem (UCTP) is rated as the main enemy by the University. UCTP aims to allocate academic courses to lecturers, the division of time, and classrooms that must carry out regularly. So that learning activities run well and smoothly until achieving an increase in the quality of education. This study recommends bibliometric analysis for this problem. Doing this is necessary to see trends or research gaps that are still possible. Search data using Publish and perish software, while data analysis using VOSviewer software. The search and data analysis results show that trend for the university timetabling problem is more likely to be solved by metaheuristic models such as genetic algorithms and simulated annealing.

***Keywords****: Bibliometric Analysis, UCTP, VOSviewer, Genetic Algorithms, Simulated Annealing*

## 1. INTRODUCTION

University faces course scheduling problems as the main villain since complexity in constructing the university timetabling. The University Course Timetabling Problem (UCTP) is allocating lecturers, students, and courses into rooms in a span of periods. Moreover, the activities must carry out regularly to run well and smoothly until achieving an increase in the quality of education.

Furthermore, we conduct this study to measure the inter-relationships and impacts of publications within a given area of research, especially in UCTP. Several limitations of the research area are fundamental courses such as assignments comparison, lecturer attendance, and lecturers' skill levels comparison [1]. Some other manifest courses as follows: (1) comparison of assignments to the total number of courses; (2) the comparison of class capacity to the capacity of classrooms; (3) the ratio of permanent lecturers to the total number of lecturers; (4) and the comparison of the number of classrooms assigned to each lecturer to the total index of classroom comparisons ready to use [2].

A schedule complex problem is a particular issue trying to find a possible allocation to demand a university education. However, universities have limited resources, so they need proper management. Moreover, creating a university schedule is also a complex process that takes the available resources into account. Suppose the schedule distribution without an appropriate calculation of the available resources will impact waste in utilization. Especially if there is no re-evaluation technique for the schedule. Availability or utilization of space becomes invalid due to a lack of timely information. Early provision of information regarding the timing of space utilization is substantial for making an accurate schedule [3].

This study does not discuss methods or ways to make scheduling at universities but provide a bibliometric review. It shows trends and research potential in the university timetable. Thus, bibliometric studies are commonly applied to skills that focus on quantitative studies of journal papers, books, or other types of writing [4]. As far as our knowledge, the discussion in this study does not have publications that publish a bibliometric analysis of the term "University Course Timetabling Problem (UCTP)". Moreover, this study uses the citation level to assess the academic quality of the journal or author.

 

The construction of this paper is as follows. In section 2 explains the literature review of UCTP. While section 3 provides the methodology of bibliometric analysis, along with the steps of the method. Section 4 presents the results and discussion. The last section presents the recommendations, conclusions, and limitations of the study.

### *1.1 Literature Review*

This section presents a brief literature review and closely related works. The timetabling problem is a complex problem experienced by a university or other education institutions. According to [5] in the timetabling issue, it consists of at least four parameters, i.e., limited time, limited resources, number of meetings, and limited number of constraints. Many combinations of these parameters result in timetabling, including university timetabling, an NP-hard problem that will take a long time to solve manually [6].

Timetabling at the university divided into course scheduling and exam schedule. Course scheduling often discusses the distribution of time, rooms, and lecturers. In contrast, exam scheduling discusses a certain amount of time in a limited number of rooms. Research on course scheduling was carried out by [6], [7], [8], [9], [10]. Meanwhile, [11], and [12] discussed exam scheduling.

In every university, it is necessary to carry out a schedule of courses carried out at almost every semester ended. The course scheduling problem is commonly referred to as University Timetable Problem. Moreover, course scheduling at a university is different to others. It's because each university has different constraints and issues that each university must fulfil. The university prepares course scheduling by coordinating different elements, for example, employees, students, teachers, subjects, etc., in a span of periods. Since the university faces the repeated activities each semester, this problem repeatedly arises. Especially when lectures or exams with different subjects meet institutional conditions or situations. Both students and teachers need to comply with them properly [10], [13].

University timetabling has a wid,e variety of complexities. Several studies describe the wide variety of complexity. For example, the consequences of improper scheduling for students with different semesters can cause schedules to clash [14]. There are several choices of algorithmic approaches that can be applied to solve the university timetabling problem. One practical approach is the use of meta-heuristics, such as genetic algorithms and data retrieval technologies that successfully provide optimization solutions [15],[16],[17]. They present the university schedule problem as lecturer allocation, division of planned time and class. Moreover, the calculation shows that the recommended algorithm can get a solution that is close to the right compared to the solution generated manually [18].

Furthermore, university timetabling literature review studies are hard to find. Theppakorn and Pongcharoen identify 14 hard constraints and 18 soft constraints from the previous researches [3]. The widely used hard constraints are: (1) Students can only have one lecture at a time; (2) A lecturer can only deliver one lecture at a time; and (3) Lecturers' unavailability is considered. Moreover, the widely used soft constraints are: (1) The timetables for rooms should be as compact as possible; (2) Lecturers can specify times when they prefer not to lecture; (3) Some lectures should not take place late in the evening; (4) The number of students having lunch at a given time should be controlled; (5) Classes should have lectures either in the morning or in the afternoon.

The limited studies of literature reviews on the UCTP area creates opportunities to see how the researches are going and what recommended urgencies the UCTP nowadays. The new world situations such as pandemics and lecture modes also provide opportunities that might influence the direction of the research in UCTP.

## 2. METHODS

We conduct the methodology of this research using five steps in Ilhami et al. (2019) [19]. We present the five steps in detail as follows.

### 2.1 *Defining Search Keyword*

Bibliometric screening is arranged based on keywords in the course schedule. Search keywords including "course scheduling" and "university timetable". Thus, we exclude course schedules at school or training programs.

### 2.2 *Initial Search Result*

We conduct the initial search using Publish and Perish Software version 7.32.3373.7310, with applying Google Scholar and Scopus database. The search process begins by using the keyword "course scheduling". From the Scopus database resulted in 200 articles, while the Google Scholar database has 998 articles. And then we tried with the keyword "university timetable". With this keyword, the Scopus database found 200 articles. Finally, the Google Scholar database discover 999 papers.

Furthermore, we find that publish and perish software shows the exploration with the Google Scholar database provide more articles than the Scopus database. This is caused by publish or perish software limits to 1000 articles of the Google Scholar database. While using the Scopus database, articles are limited to 200 articles.

### 2.3 *Refinement of Search Result*

At this stage, we conduct a selection of the existing articles. The refinement criteria used in this study are as follows.

1. Articles are from journals.
2. The citation value is above four.
3. The abstract fits the UCTP problem.

After conducting the refinement, we find 14 articles in the Google Scholar database and 23 articles in the Scopus database that match the UCTP problem. Moreover, we find 47 articles in the Google Scholar database and 17 articles in the Scopus database while using the keyword university timetabling. Table 1 shows the results of article refinement.

### 2.4 *Compiling the Initial Data Statistics*

After the refinement process, the next step is to download all the remaining articles in CSV (comma-separated value) format. This format is required to combine the remaining articles from Scopus and Google Scholar databases easily. Furthermore, by using this method we may complete all metadata we need to provide a better source for mapping the remaining articles. Moreover, we may make sure there is only one unique data in the CSV file. Finally, we find 62 unique articles in the CSV file. Fig. 1 shows the grouping of the 62 articles by year.

**Table 1.** The result of article refinement

| Keyword | Google Scholar Database | Scopus Database |
|---|---|---|
| Course scheduling | 23 | 14 |
| University scheduling | 47 | 17 |

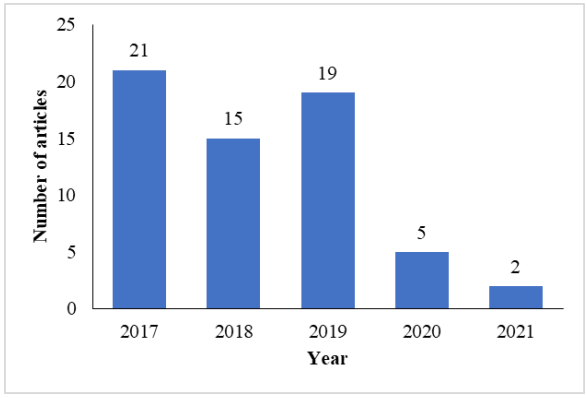


**Figure 1**. The grouping articles by year

Furthermore, we conduct these 62 articles mapping using VOSviewer software. We analyze the mapping results using “Co-occurrence” which displays a visualization of the network between keywords. While the calculation method to find out the most dominant references uses "full counting", which counts the articles as they are.

VOSviewer provides a visualization of the dataset, in this case, a journal article. VOSviewer software provides three visualization outputs, which are: (1) network visualization; (2) overlay visualization; and (3) density visualization.

### 2.5 *Data Analysis*

Articles search with Publish and Perish Software version 7.32.3373.7310 is processed using PC with Inter® Core™ i5-8265U CPU @ 1.60GHz 1.80 GHz, 8.00 GB RAM. Under the 64-bit operating system, X64-based processor. Search results with Google Scholar yielded nearly 900 articles and 200 articles from the Scopus database. The compiling results of the initial data statistics of the two finally present 62 papers with the keywords course scheduling and university scheduling.

## 3. RESULT AND DISCUSSION

Based on the visualization from VOSviewer, we knew that research on university timetabling is quite in demand. The solution to this university timetabling problem uses more heuristic and metaheuristic methods. It can be seen from the mapping of existing articles. Fig. 2 shows a visualization of the VOSviewer.

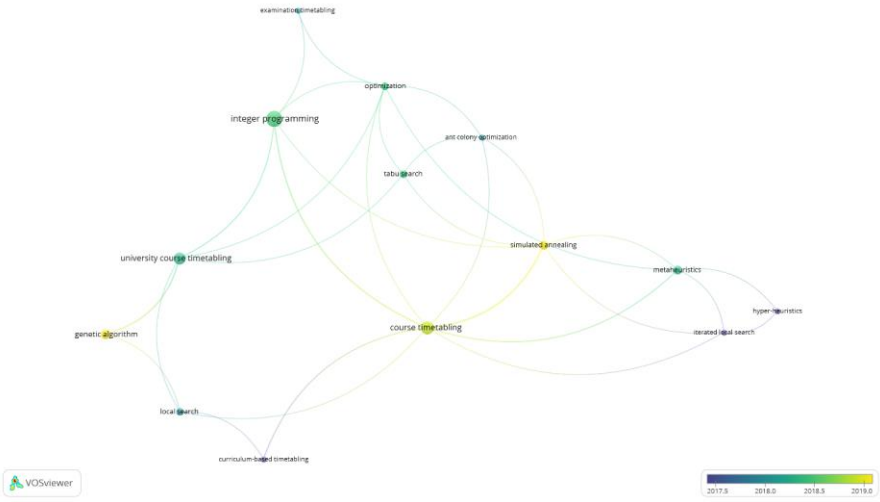


**Figure 2.** Overlay visualization university timetabling

Figure 2 shows that the large circle image is the item that often appears in VOSviewer is "integer programming", then "university course timetabling" and "course timetabling". The colours in the overlay visualization show the current trend in university timetabling problems. Dark colours indicate previous events or trends. Meanwhile the lighter colours indicate current trends in the research area.

The lighter colour as expressed in Figure 2 are genetic algorithm (GA) and simulated annealing (SA). These methods belong to metaheuristic algorithm group. The genetic algorithm known as an effective algorithm for solving NP-hard problem. While the simulated annealing algorithm is still less popular than genetic algorithm. Genetic algorithms work on the principles of genetics. While the SA algorithm moves based on temperature increase in the steel annealing process.

Research trends in university timetabling problem are in this area. Completion of solutions is prioritized by using heuristic and metaheuristic models rather than making mathematical models. We may combine the two metaheuristic models to produce a more efficient solution. Such as by changing the rules for generating parameters, which merges the two algorithms. However, mathematical models can still be used as an alternative. Especially, to describe the university timetabling problems in detail.

## 4. CONCLUSIONS

This study investigates bibliometrics for university scheduling. We used Publish and perish software to search for initial articles and then performed analysis using VOSviewer. The search for articles was carried out in 2017-2021 using the keywords university timetabling and course timetabling. Tracking did use Google Scholar and Scopus databases, with inclusion criteria: (1) 2017 – present, (2) subject area: computer science, mathematics, and decision science, (3) limited to journal.

There are 62 relevant articles in this study. The results show that there are still research gaps, especially regarding the proposal improvement of solution method especially in genetic algorithm and simulated annealing. Keyword “course timetabling” and “university timetabling” often represented by several keywords and could lead to a miss calculation of occurrences and total link strength. Thus, we can use another keyword.

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