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A Heuristic for Scheduling Examination to Room Based on Exam Duration Length

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Solving the real world university timetabling problem is crucial and important in order to satisfy not only the given constraints but also to maximise the needs of the students. Most of the previous researches emphasized on producing a good quality solution of the clash free timetable by focusing on spreading exams over timeslots. Apart from that, less attention had been given on minimising the *disturbance* of the exam. We have divided the process of developing the timetable into two major phases, *Exam-Timeslot assignment phase* and *Exam-Room assignment phase*. In this paper, we focused on the second phase by assuming that all exams have already been assigned to timeslots. We introduced a new soft constraint, i.e. *exam duration length* that needed to be considered when assigning examinations to rooms. This constraint was identified through the short survey on the satisfaction of the *Universiti Kebangsaan Malaysia* (UKM) students towards the UKM examination timetabling. Based on the survey, 73.5% of the 83 respondents preferred the exams that are scheduled in the same room, should complete at the same time. Therefore, we proposed a new formulation and heuristic that attempt to minimise this *disturbance* when students sit for the exam, i.e. our heuristic attempts to assign exams that have the same exam duration length to the same room.

Keywords: Exam room assignment, examination timetabling

1. Introduction

An educational timetabling is a part of academic management processes in any educational institutions (1). (2) found that the educational timetabling is the most studied timetabling problem by researchers. At university perspective, this type of timetabling can be divided into two major categories: (i) *university course timetabling*, and (ii) *university examination timetabling* as mentioned by (1). The examination timetabling problem is a combinatorial problem that commonly arises in universities. (3) emphasized that the problem correlation between examination-timetabling and examination-classroom assignment have not been extensively explored. These factors are important to ensure the not only to produce a feasible timetable but also the utilization of the space for the examination.

In this paper, our focus is on the examination timetabling problem that based on the examination timetable of *Universiti Kebangsaan Malaysia* (UKM). The short survey has been done on this university's students on the perception and expectation towards a flexible and conducive university examination timetable.

2. Related works

According to (4), the examination timetabling problem is a process of assigning a set of examinations into a limited number of timeslots, subject to a set of constraints, in order to produce a "conflict free" timetable. The constraints might be different from one institution to another institution and normally can be categorized into two groups: (i) *hard constraints* that need to be satisfied and cannot be violated in order to produce a feasible timetable, and (ii) *soft constraints*, that can be relaxed but are desirable to be fulfilled (5).

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(4) proposed and used the *proximity cost* to evaluate the quality of timetable by giving some weights to violation of soft constraints. (2), (6) and (7) had categorized and discussed some approaches that widely used in constructing the automated educational timetables by the researchers since a few decades ago until now. These approaches are (a) *sequential method* (4), (b) *cluster method* (8), (c) *constraint based method* (9), (d) metaheuristic methods such as *tabu search* (10), *memetic algorithm* (11), (e) *multi-criteria methods*, (f) *tabu search hyperheuristic* (12), (g) *ant algorithm* (13) and etc.

3. Finding of Survey

A set of questionnaire was distributed to UKM students who were studied in various faculties for semester July 2006/2007. The faculties involved in this survey were Information Science and Technology, Social Science and Humanity, Engineering, Law, Education, Economic and Business Studies, Science and Technology, and Islamic Studies.

The *objective* of this survey is to identify and understand the needs of students towards the university examination timetable. Out of 100 questionnaires which were randomly distributed and only 83 questionnaires had been returned and used for data analysis. From the finding, 74.7% of the respondents have to sit, in average, four to six papers for the final examination in that semester. For this situation, these papers supposedly enough spread out within the examination timetable.

Results of our survey showed that 73.5% of the respondents preferred the exams that are scheduled in the same room, should complete at the same time. When multiple exams (with difference exam duration lengths) are scheduled in a single room, *disturbance effects* such as large student movement, announcements and etc, always happen

during examination time. Therefore, we should try to minimise these *disturbances* as much as possible when assigning exams to rooms. That is, the length of examination duration can be an important factor to be considered when constructing the examination schedule. (2) and (14) only address the constraint about exam duration length but they do not formulate it as an objective function that need to be minimized. Meanwhile (12) has ignored this criterion at all by assuming that all exams have the same duration length.

4. Scenario of UKM examination

The examination period of UKM is normally conducted within three weeks of the end of current semester. Only five days (Monday till Friday) will be used to conduct the examinations for each given week. Weekends (Saturday and Sunday) are excluded except for Saturday of the first examination week that normally will be reserved for the Co-curriculum examination papers. For each examination day, it will be divided into three timeslots and can be known as *Morning timeslot*, *Afternoon timeslot*, and *Evening timeslot*, with three hours standard length duration are allocated for each timeslot. On Friday, there are only two timeslots, *Morning and Evening timeslots*, because *the Afternoon timeslot* is freed for the Muslim students to perform their Friday prayer. The interval period among these three timeslots are 30 minutes.

The duration length of UKM examination papers varies from 1 hour to more than 3 hours. The most common duration length of examination papers is 2 hours but in some cases, the examination duration length could exceed more than 3 hours and these papers are normally related to the courses offered by the Faculty of Laws. In this case study, we exclude exams for Faculty of Laws because due to exam duration length, their courses can only be scheduled to morning and evening timeslots and they should be assigned to a dedicated room.

Table 1 shows a summary of the examination room capacities. DPBestari is classified as the most important room that must to be utilised first in order to avoid the under-utilisation of room allocation and costs. Thus, optimising DPBestari usage could indirectly increase the utilisation of manpower such as invigilators that are involved during the examination period.

Table 1. Room capacity of Universiti Kebangsaan Malaysia

Room	Capacity (seat)
DPBestari	850
DGemilang	610
Dewan–DECTAR	610
LobiUtama-DECTAR	270
PSeni-DECTAR	152
LobiA-DECTAR	70
LobiB-DECTAR	70

5. Problem Definition

In general, soft constraints such as exam duration length were ignored in constructing the exam timetable. This factor is normally defined and assumed as fix duration length. By ignoring it, all the exams will be assigned to any room only with respect of student capacity of the exams involved and also the capacity of rooms. Therefore, this could indirectly increase the possibility of assigning multiple exams (that have different length) to the same room. However, in order to have a *student-friendly examination timetable*, this factor should be taken into consideration. The *disturbance factors* always happen especially during the multiple exams with multiple exam duration length.

In constructing the exam timetable, we divided the process into two phases, (i) *examination-timeslot assignment phase* and (ii) *examination-room assignment phase*. In this paper, we focus on the examination-room assignment phase and assumed that the examination-timeslot phase has already completed and all the constraints involving the exam-timeslot have already been solved such as conflicting among exams, consecutive exams and others.

6. Modeling the Exam-Room Assignment Problem

For each timeslot, we have a set of non-conflicting exams that need to be assigned to a set of rooms without violating the hard constraints. In this section, we present the formulation for exam-room assignment model. The input for the exam-room assignment problem can be stated as follows:

- N is the number of exams;
- E_i is an exam where $i \in \{1,....,N\}$;
- B is the set of all N exams, $B=\{E_1,..., E_N\}$;
- R_t is the number of available rooms for the t^{th} timeslot;
- T is the number of available timeslots;
- L_t is the number exam duration length differences in the t^{th} timeslot where $t \in \{1,....,T\}$, i.e. $L_t=0$ if all exams in the t^{th} timeslot have the same length, $L_t=1$ if there is two different exam duration lengths in the t^{th} timeslot, etc.
- β_{if} is a decision variable where $\beta_{if}=1$ if exam E_i is assigned to room f, or 0 otherwise.

The constraints of assigning exams to rooms are (for our dataset):

1) Special examinations, $E_i \in S$ where $S \subset B$ should be isolated from other exams (e.g. in UKM06-1 dataset, exam VVVA3213 requires audio), i.e. the special exams cannot share a room with other exams in the same timeslot.
2) Each exam must be assigned to a room.
3) Each lecturer has to invigilate an exam for his/her taught courses and if their courses are scheduled in the same timeslot, these exams should be assigned to the same room.
4) Wherever possible, when there are multiple exams in the same room, these exams should have the same duration length.
5) Wherever possible, each examination must be assigned to a single room.

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Constraint 1, 2 and 3 are rigidly enforced (hard constraints), whilst constraint 4 and 5 should be satisfied as far as possible. Therefore, we use *Room Length Cost*, V_{cost} as an evaluation function that attempts to minimise having multiple exams with different exam duration length to the same room. In addition, *Room Length Cost* also attempts to minimise splitting exams across different rooms. That is, we aim to minimise violating soft constraints 4 and 5. The *Room Length Cost*, V_{cost} can be defined as follows:

$$\textbf{\textit{Minimise}}\ V_{cost} = \sum_{t=1}^{T} L_t + \sum_{i=1}^{N} \rho_i \qquad \textbf{(1)}$$

Where,

$$\rho_i = \begin{cases} \sum_{f=1}^{R} \beta_{if} & \text{if} \quad \sum_{f=1}^{R} \beta_{if} > 1 \\ 0 & \text{otherwise;} \end{cases} \qquad \textbf{(2)}$$

The *Room Length Cost* counts the number of exam duration length differences in the same room (the first term), and the number of exams assigned to multiple rooms multiplied by the number of rooms for the exam. As far as we are concerned, no other researchers have formulated the objective function for assigning exams to rooms (see (3)). Therefore, we recommend future research in this area to consider our proposed objective function in evaluating the quality of generated solutions for exam-room assignment.

7. Heuristic Procedure for examination room assignment

The heuristic will assign each exam into at least one room (except for the exam that has the number of enrolment greater than the largest available room) by considering their exam duration length, with respect of the room capacity. At the initialisation step, we first rank the exams for each timeslot (B_t where t is the timeslot index) in ascending order of exam duration length, then in descending order of student enrolment. We also rank the available rooms for each timeslot (R_t where t is the timeslot index) in descending order of seat capacity.

Next, for each timeslot, the heuristic chooses the first exam in B_t and assigns it to the first room in R_t that minimises V_{cost} (equation 1) and subject to the total number of students assigned to the room that does not exceed the room capacity. The heuristic gives higher priority to the large room to be assigned with the exam that has smaller exam duration length with higher enrolment. The idea is to give more preparation time to the invigilators to prepare for the next examination timeslot. If larger room is assigned with exams that have larger exam duration length, idle time for the next timeslot is smaller. That is invigilators have short preparation time for the next timeslot. This situation should be avoided as much as possible. Wherever possible, the heuristic also attempts to assign exams with the same duration length to the same room. Assigning multiple exams with different exam duration length to the same room will increase the cost function V_{cost}. The exam-room assignment process for each timeslot continues until all exams have been assigned to rooms.

8. Conclusion and Future work

This work has proposed a new objective function, *Room Length Cost*, V_{cost}, for assigning exams to room based on the exam duration length. The aim of this work is to minimise or avoid the *disturbance* that caused by assigning multiple exams into the same room.

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