Exam Timetabling via Integer Programming: A case study at UTDT

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Abstract. This work tackles the scheduling of midterm exams at Universidad Torcuato Di Tella (UTDT). Given a set of exams as well as the students enrolled therein, the problem involves determining the date, time and classrooms for each exam. Operational constraints such as conflicts of time, room capacities and availability, as well spacing (i.e., the number of days) between exams for a student make this problem very difficult from an optimization standpoint, in particular when considering real-world instances. We explore three Integer Linear Programming based algorithms for scheduling midterm exams within this context. Based on instances obtained from real data, the methods showed to provide good quality solutions, providing the students a balanced schedule for the exams over the planning horizon.

Keywords: exam timetabling · integer linear programming · matheuristic

The Exam Timetabling Problem (ETTP) involves determining the date, time for each exam and classrooms for a given set of exams within a predefined planning horizon. The students enrolled in each exam is assumed to be known in advance, and each student can (and usually is) enrolled in more than one exam. The, the ETTP accounts not only for time and capacity constraints, but also involves finding a schedule that is convenient for the students. This problem arises in universities where, during the semester, a period (i.e., one or two weeks) is predefined in advance exclusively for evaluation purposes, with no regular classes scheduled. The classical ETTP arises as a challenging optimization problem, belonging to the class of NP-hard problems. The problem has been considered in the related literature, both with exact and heuristic approaches (see, e.g. [1,2,3]).

This is the format adopted at Universidad Torcuato Di Tella (UTDT). From the students' perspective, it is of utmost importance to avoid scheduling exams with common students at the same time to avoid overlapping. Moreover, to achieve quality planning, it is preferable that exams with common students be scheduled with at least one day of separation between them, to allow the students a better organization and preparation.

In this work, we tackle the ETTP, tailored to the context of UTDT. Among others, the following (classical) assignment constraints are considered as hard:

- Each exam must be assigned to exactly one period and exactly one room.
- Each room can be used by at most one exam per time slot.
- Each exam must be scheduled within a pre-defined set of time slots.
- Exams corresponding to the same professor must be assigned in different time slots.
- Room capacities cannot be exceeded.

In addition, to foster feasibility, some additional soft constraints are also considered. Violations of these constraints are penalized in the objective function.

- Avoid students having two or more exams scheduled in the same time period.
- Scheduling consecutive exams with a minimum number between them.
- Minimize the number of rooms used in each time slot.
- Reduce the slack of unoccupied seats in a room.

Regarding the solution algorithms, we tackle the problem using the following methods:

1. ILP: Integer programming formulation for the problem solved using CPLEX out-of-the-box.
2. 2PH-DCOMP: matheuristic that decomposes the problem into two stages. First, exams are assigned to days, relaxing the capacities constraints and imposing aggregated constraints regarding the maximum number of exams per day. Second, using as input the assignment of exams to each day, obtain a complete schedule by defining the specific time slot and room for each exam.
3. 3PH-DCOMP: First assign exams to weeks, and then apply the previous approach for each week independently using as input the output of the first phase.

We conducted computational experiments using as input the information from two semesters of 2019. Compared to the solution implemented, methods 2PH-DCOMP and 3PH-DCOMP are able to obtain good quality schedules. The key results is that both approaches are able to improve the spacing between exams while maintaining or improving the remaining indicators.

References

1. Burke, E.K., Newall, J.P., Weare, R.F.: A memetic algorithm for university exam timetabling. In: Practice and Theory of Automated Timetabling: First International Conference Edinburgh, UK, August 29–September 1, 1995 Selected Papers 1. pp. 241–250. Springer (1996)
2. Müller, T.: Real-life examination timetabling. Journal of Scheduling **19**, 257–270 (2016)
3. Qu, R., Burke, E.K., McCollum, B., Merlot, L.T., Lee, S.Y.: A survey of search methodologies and automated system development for examination timetabling. Journal of scheduling **12**, 55–89 (2009)