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Fairness in Examination Timetabling: Student Preferences and Extended Formulations

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Abstract Although they have been investigated for more than two decades, university examination timetabling problems are still considered challenging and interesting problems. In our study, we are investigating student preferences for the control of the time gaps between examinations; specifically, what students consider to be best for them and also fair between students. To support this, we conducted a survey of student views and there were two main findings. Firstly, students do have concerns about "fairness within a course", that is, fairness between students within their own course as opposed to only between students in the entire university. Secondly, they do consider some examinations harder than others and would prefer a larger time gap before such hard examinations. To account for these student preferences, we intend to extend the formulation of examination timetabling problems by modifying the objective functions, and this paper briefly describes some options. Ultimately, the aim is to automatically produce fairer examination timetables, and to increase student satisfaction.

Keywords Optimisation · Examination Timetabling Problem · Fairness

1 Introduction

Examination timetabling is a well-known and challenging optimisation problem. In addition to requiring feasibility, the quality of an examination timetable

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is measured by the extent of the soft constraint violations. Standard formulations [2, 5] have penalties for violations of various soft constraints so as to spread out the examinations as evenly as possible in the overall time period, and so give students more time for preparation. However, the standard examination timetabling formulations only minimise the average penalty per student, and this can lead to unfairness in that some students receive much higher penalties than others. Noting that poor timetables may adversely affect academic achievement, we believed that overall student satisfaction could be improved by discouraging unfair solutions. In our prior work [7], we extended the formulation in order to encourage fairness among the entire student body. (Also, for a study of fairness in course timetabling see [6]). However, the notion of "fairness" may be quite complex; hence, to determine student preferences we conducted a survey. This paper briefly reports the main results of the survey and also gives some progress towards associated extensions to the models used for optimisation.

2 Students Perspectives on Fairness

Surveys of preferences in examination timetabling have been conducted before. In [1] the survey was conducted through University registrars. A later survey [3] was directed at students and invigilators; as might be expected, it was found that "Students felt that the most important consideration while preparing the timetable is to have a uniform distribution of exams over the examination period". However, in practice, some students will have poorer distributions than others, and previous surveys had not covered their preferences on how such potential unfairness should be managed. Hence, we conducted a survey to give a deeper understanding of their preferences on the fairness and nature of the distribution of exams. Questions included to what extent issues of fairness matter to them, and the kinds of fairness they prefer. The results showed that the majority of students agreed that fairness should be taken into account. A specific question was whether the timetable should also be fair between students in the same course as opposed to only considering between students in the entire University, and a significant number of students agreed with this. This is, 'fairness within a course' should be considered as well as fairness among the entire student body. This is natural as the students on the same course are their 'competitors' and also colleagues, and dissatisfaction may well arise when a fellow student has much more time for revision before an exam. Note that the notion of 'within a course' may be extended to 'within a cohort' with various different choices for cohorts. For example, a 'cohort' could refer to 'year of study', and justified on the grounds that fairness between final year students is more important than for first years (as the exams typically contribute more to the final degree).

The survey also asked whether they find some exams harder than others, and (unsurprisingly) students agreed with this. They also generally agreed that they need more time for preparation before harder examinations. Presumably a problem with accounting for this is the need to determine perceptions of the hardness of examinations, but, maybe it could be collected from students opinion after taking the examinations, or by simply asking students in advance to nominate which examinations needed more preparation time.

3 Towards an Extended Formulation

A commonly used fairness measure is the 'Jain's Fairness Index' (JFI) [4]. Suppose a set C of students, has associated penalties $P(C) = \{p_i\}$, with mean value, $\bar{P}$, and variance σ_P^2. Then a reasonable measure of the width, and so fairness, is the standard 'Relative Standard Deviation' (RSD) defined by $RSD^2 = \sigma_P^2/\bar{P}^2$. The JFI is then a convenient non-linear function of the RSD:

$$J(C) = \left(1 + RSD^2\right)^{-1} = \frac{\left(\sum_{i\in C} p_i\right)^2}{|C| \sum_{i\in C} p_i^2} \tag{1}$$

and it is (arguably) 'intuitive' as it lies in the range $(0, 1]$ and a totally fair solution (all penalties equal) has JFI=1. For a course (or cohort), C_k, the 'fairness within a course' $J(C_k)$ can be defined by simply limiting to the penalties for the students within C_k. A candidate objective function to enhance fairness within cohorts is then simply the sum of JFI values per cohort:

$$\text{(maximise)} \quad \sum_k J(C_k) \tag{2}$$

As an illustration, consider the case of 2 cohorts with 2 (groups of) students each, and with $P1$ and $P2$ giving the set of penalties for cohorts 1 and 2. Suppose there are two candidate solutions $S1$ and $S2$ with values:

Soln	P1	P2	avg(P)	J(all)	J1	J2	avg(J1,J2)
S1	{4,4}	{2,2}	**3**	0.9	1.0	1.0	**1.0**
S2	{4,2}	{4,2}	**3**	0.9	0.9	0.9	0.9

where J(all) is the JFI over all the students and J1 and J2 are the JFI values for the two cohorts. The two solutions have the same overall average penalty, avg(P), and overall JFI. However, we believe that students would prefer solution S1 as it is fairer within each cohort, and this is captured by the higher value of J1+J2. Of course, the situation will not always be so simple. Consider, a second example but with 3 students per cohort, and 3 solutions as follows:

Soln	P1	P2	avg(P)	J(all)	J1	J2	avg(J1,J2)
S1	{8,8,9}	{2,2,2}	5.2	0.725	0.997	1.0	**0.998**
S2	{8,8,2}	{8,2,2}	**5.0**	0.735	0.818	0.667	0.742
S3	{7,7,9}	{4,3,3}	5.5	**0.852**	0.985	0.980	0.983

S2 is the lowest overall penalty and would be the standard choice, but is not the fairest both overall and within the cohorts. Potentially, S1 might be preferred because it is most fair within the cohorts, or maybe S3 because it is most fair between all the students. It suggests that there should be a trade-off between overall total penalty, overall fairness, and fairness within cohort. Note that alternatives to the objective function in (3) should also be considered; e.g. for some suitable value of p, to simply minimise the sum of p'th powers of RSDs:

$$\text{(minimise)} \quad \sum_k RSD^p(C_k) \tag{3}$$

or maybe even use an extended version of the JFI with $JFI_p = (1 + RSD^p)^{-1}$.

Details of how best to modify the formulation and solver to account for this multi-objective problem is ongoing work. Finally, for the 'hardness', of exams, we plan to simply give a difficulty index for each exam and use this in modified definitions of penalties, e.g. so that having an exam the day before a hard exam is more penalised that if it were before an easy exam.

4 Conclusion

It is intended that this work will contribute to the generation of examination timetables that match student preferences and enhance their satisfaction. The main contribution is to also account for 'fairness within a cohort of students', rather than only between the entire student body. Ongoing work is investigating how to modify the solvers so as to account for the extended objective functions. Future work will then also study which solutions of the multi-objective problem best match the student preferences, as well as the balance with requirements of the other stakeholders such as teachers and invigilators.

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