Developing a Comprehensive and Multi-Objective Mathematical Model for University Course Timetabling Problem: A Real Case Study

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Abstract

In this paper, a multi-objective and comprehensive mathematical model is presented to address a course timetabling problem. The purpose of the model is to allocate the courses to timeslots, so that the following constraints are observed: availability times of instructors, the number of available classrooms in faculties, the eligibility of classes and timeslots for the courses, overlap prevention for teaching hours of each instructor, the maximum working times allocated to each instructor in day, overlap prevention for courses within course groups. Also, this paper aims to increase satisfaction degree of instructors by maximizing their preferences to teach in their desired day and timeslot, as well as providing more times to do researches. The proposed model is coded in GAMS and solved by the augmented epsilon-constraint method for a real case study. Finally, TOPSIS method is employed in order to select the most favorable solution among the Pareto solution. The results were approved and welcomed by the faculty.

Keywords
Timetabling, University timetabling, multi-objective programming model, the augmented epsilon-constraint method, TOPSIS method

1. Introduction

Problem-solving of educational timetabling for large institutions is greatly difficult; since these institutions include a large number of students, instructors, courses, and classes which are most of the time contradictive in terms of their conditions and objectives. Therefore, each solution must take into account various decision variables and constraints. Due to numerous constraints and the complexity of their relationships, this problem is classified into a group of NPcomplete problems [1]. Accordingly, manual timetabling programming is very time-consuming even for experienced managers. Furthermore, the obtained solution may not be satisfactory in some aspects. This challenge led some researchers to pay a special attention to the problem of educational timetabling.

The problem of university courses timetabling, which happens at the beginning of each term, is the process of scheduling a set of courses that should be presented over an academic term and includes activities such as assignment of instructors to the courses, allocation of courses to time slots during a set of days over a week. Generally, the inputs of the above process include a list of presented courses, available instructors, and available educational spaces (class, laboratory, and workshop). There are many constraints impacting on this problem:

- Limited number of time slots available in each day,
- Limited number of available classes in each day,
- No more than one class must be held in each class in every time slot,
- In each time slot, the number of the presented courses must not exceed the number of available classes,
- The classes considered for each course must be in accordance with the type of the course,
- Students' compulsory courses in each semester should not be presented simultaneously,
- Considering the available hours of the instructors over week,
- No overlap between the courses of every instructor during day,
- Avoiding over-work for each instructor during day,
- Avoiding consecutive over-teaching for each instructor during day,
- eligibility of the time slots for its allocated course,
- Appropriateness of time interval (in day) between required number of sessions for holding a class over week.

Not considering any of the above aspects can lead to an infeasible timetable in practice. Hence, in this study, all the above constraints have been considered in the developed model.

This study proposed a multi-objective mathematical model for university course timetabling problem. The objectives are to maximize the preferences of instructor, and minimize the time spent by instructors for teaching which leads to increase in the available time for research and addressing research affairs of students in graduate and postgraduate degrees. Given the conflict between objectives of multi-objective problems, there is no single solution in which all objectives are optimal, therefore a set of non-dominated solutions would be obtained as optimized solutions which are called Pareto solutions for a real case study. Finally, the most desirable Pareto solution would be selected through TOPSIS method.

This study is organized as following. In section 2, the research literature has been reviewed and research contribution clarified. In section 3, problem definition and the mathematical model are presented. The solution method is described in section 4. In section 5, a real case study is presented., The computational results are provided in section 6. Finally, in section 7, a summary and recommendations for future research are discussed.

2. Literature review

Timetabling is one of the important research area which has been widely studied by researchers since 1960's [2]. This problem is categorized into three classes as follows [3]:

- School time tabling which includes course scheduling for a high school;
- Examination timetabling which deals with scheduling examinations for university courses;
- Course time tabling which is the problem for weekly scheduling for courses presented over an academic term. This problem, depending on providing or not providing curricula by the university and existence of conflict between the provided courses in curricula, is divided into two types, namely, curriculum-based course time tabling and enrollment-based time tabling. In this section, we focus on the relevant studies in the course time tabling area which is also known as university time tabling.

Various approaches have been proposed to solve the timetabling problem. One of the first and most broadly used approaches is to use the graph coloring algorithm to solve the timetabling problem. The goal of the graph coloring problem is to find the minimum number of colors needed to color the vertices of a graph so that neither of the two vertices are homogeneous, which is introduced for solving the timetabling problem by Welsh and Powell [4], and further studies by Burke, Elliman [5], Dimopoulou and Miliotis [6], and Neufeld and Tartar [7].

Many mathematical models in this area are presented in the form of integer linear programming. For instance, Daskalaki, Birbas [8] introduced a binary mathematical model to minimize the costs of allocating courses to time slots according to required sessions, consecutive hours, and existing operational limitation. Al-Yakoob and Sherali [9] proposed a mathematical model by the aim of minimizing class conflicts in Kuwait University. They developed a two-stage approach to solve the model. Since some classes are male-specific, female-specific or joint, they initially determined the time slots considering the gender of the different classes. Then, and in the second stage, they allocated lecturers to the classes determined in the prior stage. Similarly, Al-Yakoob and Sherali [10]applied a two-stage approach and also a column generation method for solving a timetabling problem for a high school in Kuwait. Sarin, Wang [11] presented an integer model for a timetabling problem with the aim of minimizing the traveled distance between classes by the lecturers. Then, they employed the problem for a university in Virginia Tech and solved it by applying Bender's partitioning. Domenech and Lusa [12] developed a mixed integer linear programming model to balance teaching loads of lecturers by considering lecturers' preferences in the school of industrial engineering of Barcelona. In the presented model, lecturers were classified based on expertise, and then, the total preferences of lecturers were maximized according to the rating levels of lecturers.

Since solving the timetable problem needs the huge computation time, heuristics and meta-heuristics algorithms have been used by researchers for timetabling problems. Among the most widely used algorithms, genetic algorithm [13-15], tabu search [16, 17], and Simulated annealing [18] can be mentioned. Lewis [19] reviewed the heuristics and meta- heuristics algorithms used in timetabling problem. Various hybrid algorithms have also been used by researchers to solve the above-mentioned problem, among which a hybrid genetic algorithm and tabu search [20], a hybrid simulated annealing and ant colony system and tabu search with Ant Colony System [21], and Harmony Search algorithm and the Bees algorithm [22] can be noted.

Most studies conducted in this area are single-objective in which minimizing violation of soft constraints is considered as objective function, and few studies have been focused on optimizing multi-objective models and multi objective optimization approaches. Datta, Deb [23] presented a bi-objective model with the aim of minimizing average number of free time slots between two classes of students and number of consecutive classes for lecturers. Then, they developed a NSGA-II algorithm for solving the model. In another study, Abdullah, Turabieh [24] , presented a two-objective model to minimize the number of time slots during which a student waits between two classed as well as the deviations of soft limitations. In order to solve the model, they developed a NSGA-II algorithm. Thepphakorn, Pongcharoen [25] developed a new multi-objective model by the aim of minimizing the operational costs and the number of inadequate chairs in a course time tabling problem in a university in Thailand. Then, to solve it, they used a multi objective cuckoo search algorithm.

A brief survey on the literature shows that, the interference possibility of predetermined timeslots for courses or lecturers, and also the courses related to students who enter the university in the same semester have paid low attention in the previous studies, while this issue is very common in universities. Furthermore, legal constraints such as maximum work-hour of instructors per day and also their maximum consecutive work-hours per day have not been considered. Also, in the present research, the lecturers' level of satisfaction would be enhanced by considering their preferences and providing more opportunities to do their research works. In addition, for making the model more real, other constraints such as available hours of instructors, classes' adequacies, and appropriateness of the timeslots for holding the course have been considered. Therefore, the main contribution of this model is considering all the above-mentioned aspects in a novel and multi-objective model.

3. Problem description and mathematical modeling

In this section, a comprehensive and multi objective 0-1 programming model is developed for the weekly planning problem of the university course timetable. This problem consists of a set of courses to assign to a set of days (d=1, 2…, D), a set of time slots (l=1, 2…, L), and a set of classes (r=1, 2…, R) in which the course can be taught in it. In the model, we aim to maximize the sum of preference level of instructors and minimize the sum of the working days of ones in week.

3.1. Assumption

- All course must be schedule.
- The timeslots may overlap to each other.
- Some courses cannot assign to each timeslot.
- The required number of sessions (in week) of each course is predetermined.
- The instructors in charge of each course is predetermined.
- Any of primary courses related to the students who enter the university in the same semester, are not allowed to overlap.
- None of courses related to an instructor are allowed to overlap.

3.2. Sets and indices:

i	index of instructor
j	index of course
l,l'	index of timeslot

r	index of class
d	index of day
k	index of semester
j_i	set of courses which instructor *i* is their responsible
$A(k)$	set of courses related the students who enters university from the semester *k*
Mc	set of courses needed more than one timeslot in week

3.3. Parameters:

$pref(i,d,l)$	preference score of instructor *i* for teaching in day *d* and timeslot l
$B(j,r)$	if class *r* is eligible for course *j*, its value is one, otherwise zero.
p_j	required number of timeslot for course *j* in week
$\alpha(j,l)$	if timeslot *l* is suitable for course *j*, its value is one, otherwise zero.
$A\ (i,d,l)$	if instructor *i* is available in day *d* and timeslot l, its value is one, otherwise zero.
$Max_{working\ time}$	maximum working time that each instructor can teach in day (in min)
$maxc$	maximum working time that each instructor can consecutively teach in day (in min)
$\lambda_{l,l'}$	if timeslots l and l' do not overlap, its value is one, otherwise zero.
$g_{jdd'}$	if the distance between day *d* and d' is not suitable enough for teaching course j in week, its value is one, otherwise zero.
$\delta_{l,l'}$	if timeslots l and l' do not overlap and are consecutive, its value is one, otherwise zero.
G	a big number
p_j	the duration of course *j* (in min)
pl_l	the length of time slot l (in min)

3.3. Variables

x_{jlrd}	if course *j* is taught in timeslot l , day *d*, and class *r*, its value is one, otherwise zero.
y_{jr}	if course *j* is taught in class *r*, its value is one, otherwise zero.
N_{id}	if instructor *i* is taught at least one course in day *d*, its value is 1, otherwise zero.

3.4. The mathematical model

$$Min\ Z_1 = \sum_i \sum_d N(i,d) \tag{1}$$

The first objective function (i.e. Eq.1) try to design a timetable for the instructors, so that they teach in less days of week and accordingly, they will have more time to do research works.

$$Max\ Z_2 = \sum_i \sum_{j \in J_i} \sum_r \sum_l \sum_d x_{jlrd} \times pref(i,d,l) \tag{2}$$

$$\sum_r y_{jr} = 1$$

$$\forall j \quad (3)$$

$$y_{jr} \leq B(j,r)$$

$$\forall j,r \quad (4)$$

$$\sum_d \sum_l x_{jlrd} = p_j\ y_{jr}$$

$$\forall j,r \quad (5)$$

$$\sum_d \sum_r x_{jlrd} \leq dur_j\ \alpha(j,l)$$

$$\forall j,l \quad (6)$$

$$\sum_{r}\sum_{j\in J_i} x_{jlrd} \leq A\ (i,d,l) \qquad \forall i,d,l \quad (7)$$

$$\sum_{r}\sum_{l}\sum_{j\in J_i} x_{jlrd} \times dur_j \leq Max_{working\ time} \qquad \forall i,d \quad (8)$$

$$\sum_{r}\sum_{j\in J_i} x_{jlrd} + \lambda_{l,l'} \sum_{r}\sum_{j\in J_i} x_{jlrd} \leq 1 \qquad \forall i,d,l,l' | l \neq l' \quad (9)$$

$$\sum_{j} x_{jlrd} \leq 1 \qquad \forall d,l,r \quad (10)$$

$$\sum_{r} x_{jlrd} + \sum_{r} x_{j'lrd} + \lambda_{l,l'} \sum_{r} x_{j'l'rd} \leq 1 \qquad \forall k, \forall j,j' \in A(k), \forall d, \forall l,l' | l \neq l' \quad (11)$$

$$\sum_{r}\sum_{l} (x_{jlrd} + x_{jlrd'}) \leq 2 - g_{jdd'} \qquad \forall j \in Mc, \forall d,d' \quad (12)$$

$$\sum_{r}\sum_{j\in J_i} x_{jlrd} \times pl_l + \delta_{l,l'} \sum_{r}\sum_{j\in J_i} x_{jl'rd} \times pl_{l'} \leq maxc \qquad \forall i, \forall d, \forall l,l' | l \neq l' \quad (13)$$

$$G \times N_{id} \geq \sum_{r}\sum_{l}\sum_{j\in J_i} x_{jlrd} \qquad \forall i,d \quad (14)$$

$$N_{id} \leq \sum_{r}\sum_{l}\sum_{j\in J_i} x_{jlrd} \qquad \forall i,d \quad (15)$$

$$x_{jlrd}, N_{id}, y_{jr}\ \epsilon \{0,1\} \quad (16)$$

The first objective function (i.e. Eq.1) try to design a timetable for the instructors, so that they teach in less days of week and accordingly, they will have more time to do research works. The second objective function (i.e. Eq.2) maximize the sum of instructors' preferences to teach in their desired day and timeslot. Constraint (3) states that each course must be assigned to one class. Constraint (4) ensures that course *j* is not assigned to the class which is not eligible for it according to its capacity and equipment. Constraint (5) states that if course *j* is assigned to class *r*, as many as required, it should be occupied a number of timeslot in week. Typically, the two-units courses require a 100-minute time slot, while the three-unit courses require two 75-minutes timeslots. Constraint (6) ensures that each course, depending on the number of its units, is assigned to the suitable timeslot. The constraint (7) check the availability of instructors in days-timeslots and prevent assigning their courses to the days-timeslots that they are not available in them. In order to improve the convenience of instructors, they should not teach more than a certain limit per day. Constraint (8) ensures this condition. Constraint (9) prevents overlapping the timeslot assigned to courses of an instructor in a day. Constraint (10) states that at most one course can be assigned to a timeslot in a class and day. Constraint (11) prevents overlapping of the courses offered for the students who enters university in the same semester. Equation (12) ensures that the minimum distance (in days) is established between the sessions of the course which need than one timeslot in week. Constraint (13) states that each instructor is not allowed to teach more than a certain limit in a day consecutively. Constraints (14) and (15) bind the x_{jlrd} and N_{id} variables together. constraint (16) shows the variable domain in the model.

4. Solution methodology

4.1. The augmented epsilon-constraint method

Several approaches are presented to solve multi objective mathematical models in the literature such as goal programming, multiple response optimization [26], epsilon-constraint method, weighted sum method [27], Tchebycheff-based methods and fuzzy programming approaches [28]. Epsilon-constraint method is one of the most extensively employed methods in the literature [29-32]. This method optimizes only one objective while converting remained ones into the constraints [33]. Assume the following model with two objective functions.

$$\begin{aligned}&\text{Max } (f_2(x))\\&\text{Min } (f_1(x))\\&\quad s.t.\\&\quad x \epsilon S,\end{aligned} \tag{17}$$

Decision variables' vector is denoted by x and S is the feasible region. In epsilon-constraint method, the multi objective model is formulated as follows:
To reach the efficient solutions for the following model, we must change the RHSs values of the constrained objective functions, parametrically.

$$\begin{aligned}&\text{Min } f_1(x)\\&s.t.\\&f_2(x) \geq \varepsilon\end{aligned} \tag{18}$$

Although the epsilon-constraint method has a number of advantages over the other methods, it has some weakness as well. The key weakness is the possibility of producing weakly efficient solutions. accordingly, Mavrotas [34] offered a new version of the epsilon-constraint method named augmented epsilon-constraint method (AECM).In this method, at first, it is needed to form a pay-off table to calculate the range of the objective functions. Then, the range of the constrained objective function should be divided to *r* equal intervals, to calculate various values of *ε* as follows:

$$n_k = f_2^{max} - f_2^{min}; \qquad \varepsilon = f_2^{\max} - \frac{n_k}{r} \times l \quad l = 0, \ldots, r-1; \tag{19}$$

Therefore, the formulation of augmented ε-constraint method is changed as follows

$$\begin{aligned}&\min \left[f_1(x) - eps \times s \right]\\&\text{s.t.}\\&f_2(x) - s = \varepsilon\\&x \in X \text{ and } s \in R^+\end{aligned} \tag{20}$$

where *S* is the slack variables and *eps* is an sufficiently small.

4.2. TOPSIS method

Multiple-criteria decision-making (MCDM) is a sub-discipline of operations research that explicitly evaluates multiple conflicting criteria in decision making. MCDM approaches are widely employed in various contexts such as safety [35, 36], improvement in healthcare systems [37], manufacturing area [38]. TOPSIS is one of the best methods for multi attribute decision making based on the Measures of dispersion in the statistics. This method is based on comparing the alternatives with two positive and negative ideal solutions [39]. The alternative which have the least distance from positive ideal solutions and the maximum distance from negative ideal solutions will have higher rank [40]. In this method, the ideal solution refers to the one which is the best in all aspects and the alternatives are ranked according to the similarity to the ideal solutions. For example, if there are *n* criteria and *m* alternative, the ideal solution is the option that results in the best value for each criterion. The TOPSIS method consists of eight steps as follows:
Step 1- Formation of decision matrix based on *n* criteria and *m* alternatives:

$$A_{ij} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{bmatrix} \tag{21}$$

where a_{ij} is the function of alternative *i* in relation to criterion *j*.

Step 2- Standardization of decision matrix through the Eq. (22).

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{i=1}^{m} a_{ij}^2}} \quad , i = 1, \ldots, m \text{ and } j = 1, \ldots, n \tag{22}$$

Step 3-Determination of the weight vector $W_{n \times n}$ consists of weight of each criterion subject to $\sum_j w_j = 1$

Step 4- Formation of the dimensionless weighted decision matrix (V_{ij}) through Eq. (23)

$$(\mathrm{V}_{ij}) = \mathrm{R}_{ij} \times W_{n\times n} \tag{23}$$

Step 5 – Determination of the positive ideal A^+ solution and negative ideal A^- solution through Eqs. 24 and 25.

$$V_j^{+} = \left\{ \left(\max\left(V_{ij}\right) \middle| j \in j^{+} \right), \left(\min\left(V_{ij}\right) \middle| j \in j^{-} \right) \right\} \quad ,j = 1,...,n \tag{24}$$

$$V_j^{-} = \left\{ \left(\min\left(V_{ij}\right) \middle| j \in j^{+} \right), \left(\max\left(V_{ij}\right) \middle| j \in j^{-} \right) \right\} \quad ,j = 1,...,n \tag{25}$$

where j^+ and j^- are the sets of "benefit criteria" (i.e. higher values are suitable) and "cost criteria" (i.e. lower values are suitable) respectively.

Step 6- Calculation of distance from the positive ideal and negative ideal solution by Euclidean distance measure through Eqs. 26 and 27.

$$d_i^{+} = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^{+}\right)^2} \tag{26}$$

$$d_i^{-} = \sqrt{\sum_{j=1}^{n} \left(V_{ij} - V_j^{-}\right)^2} \tag{27}$$

Step 7 – Determination of relative closeness (C_i) coefficient of each alternative to the ideal solution through the Eq. (28)

$$C_i = \frac{d_i^{-}}{d_i^{-} + d_i^{+}} \tag{28}$$

Step 8- Ranking the criteria based on the magnitude of (C_i) where $0 \le C_i \le 1$.

5. Case study

In this section, we provided a real case study to show the aplicability of the proposed model. The case study is related to design of the course timetable in the second semester of the faculty of industrial engineering and systems of a govermental university located in Tehran,Iran. The required data are collected from the education director of the faculty. It should be noted that this faculty is exclusively devoted to the students with master and PhD degree. This faculty consists of seven classes that can be used in six time slots, inculing (8:00-9:20), (9:30-10:50), (11:00-12:20), (13:20-14:40), (14:50-16:10), and (16:20-17:40). In the current semester, there are 37 courses for scheduling, and 23 instructor who are responsible these courses. Table 1 shows the list of the courses, the instructor in charge of the courses, and their required number of time slots. Notablely, due to the lack of satisfaction of the faculty, the names of the instructors are not announced and they are shown only with the proprietary code.

Table 1. Information of the case study

Course No.	Course title	Instructor code	NRT*
1	Familiarity with health systems	A	1
2	Biostatistics and health indicators	B	1
3	Standards, Validation and Evaluation Criteria for Health Systems	C	2
4	Reliability	C	2
5	Marketing	C	2
6	financial management	C	2
7	Combined optimization	D	2
8	Operation Research	D	2
9	Stochastic processes	D	2
10	Stochastic optimization	F	2
11	Scheduling	F	2
12	Designing industrial systems	F	2
13	Operation Research in healthcare	G	2
14	Methodology and research design	G	1
15	Network Theory	G	2

Course No.	Course title	Instructor code	NRT*
16	Multiple Criteria Decision Making	H	2
17	System dynamics	H	2
18	Data mining in healthcare	I	2
19	research methodology	J	1
20	simulation of healthcare systems	K	2
21	experiment design	L	2
22	engineering data analysis	L	2
23	Data-driven modeling in health	M	1
24	Investment strategies and financial evaluation	N	2
25	Selected topics in financial engineering	N	2
26	Econometrics	O	2
27	system engineering	P	2
28	decision-making theory	Q	2
29	Principles of Financial Engineering	R	1
30	Emerging financial markets	R	2
31	Financial Expert Systems	R	2
32	Econometrics	S	2
33	Financial statements analysis	T	2
34	research methodology	U	1
35	investment management	V	2
36	Comprehensive quality management	W	2
37	Project management and planning	X	2

*NRT: Number of required timeslots

6. Computational results

The proposed model is solved by AECM and CPLEX solver in GAMS sofware for the presented case study. The results derived from solving the model by AECM are presented in Table 2. As the results, four non-dominated solutions are obtained,depicted in Figure 1. Notablely, to implement the augmented epsilon-constraint method, we coverted the second objective into a constraint.

In order to find the most favorable schedule among the non dominated solutions, TOPSIS method is employes. Therefore, we ask education manager to determine the importance level of each objective function.(see w_1 and w_2 in Table 3). The results are shown in Table 3. As the results, solution 1 is most favorable solution,depicted in Figure 2 .

Table 2. The results obtained by AECM for the case study

l	CPLEX result	CPU time(s)
0	45	1.08
1	44.999	1.53
2	44	0.91
3	43.999	1.21
4	43	1.67
5	41.802	5.23
6	41.801	6.63

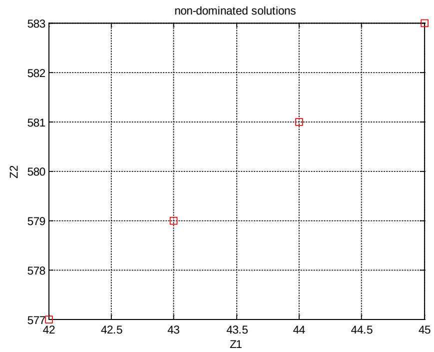

Figure 1. The non-dominated solutions

Table 3. The results of TOPSIS method

		Criteria					
		OF1	OF2				
	Criteria type	Min	Max				
Pareto solution	Weight	$w_1 = 0.3$	$w_2 = 0.7$	d_i^+	d_i^-	CC_i	Rank
sol 1		42	577	0.003620663	0.010341412	0.740678753	1
sol 2		43	579	0.004208214	0.006999115	0.624512288	2
sol 3		44	581	0.006999115	0.004208214	0.375487712	3
sol 4		45	583	0.010341412	0.003620663	0.259321247	4

Course No.	Saturday	Sunday	Monday	Tuesday	Wednesday	Class No.
1			11:00-12:20			4
2			14:50-16:10			5
3	11:00-12:20				16:20-17:40	4
4	9:30-10:50	11:00-12:20				6
5	8:00-9:20				11:00-12:20	3
6		13:20-14:40			14:50-16:10	3
7	9:30-10:50		14:50-16:10			3
8	11:00-12:20		13:20-14:40			6
9	14:50-16:10		14:50-16:10			5
10	14:50-16:10	13:20-14:40				1
11	9:30-10:50	9:30-10:50				2
12	8:00-9:20	11:00-12:20				1
13	13:20-14:40				13:20-14:40	3
14					8:00-9:20	1
15	16:20-17:40				14:50-16:10	2
16		8:00-9:20		9:30-10:50		1
17		8:00-9:20		9:30-10:50		7
18	13:20-14:40	16:20-17:40				2
19	13:20-14:40					1
20	13:20-14:40				14:50-16:10	7
21	9:30-10:50	8:00-9:20				4
22	8:00-9:20	16:20-17:40				7
23					9:30-10:50	7

Course No.	Saturday	Sunday	Monday	Tuesday	Wednesday	Class No.
24	11:00-12:20	14:50-16:10				2
25	8:00-9:20	9:30-10:50				4
26	11:00-12:20	8:00-9:20				5
27	14:50-16:10			9:30-10:50		3
28	9:30-10:50			16:20-17:40		7
29		8:00-9:20				3
30		11:00-12:20	13:20-14:40			3
31		16:20-17:40		14:50-16:10		3
32	8:00-9:20		8:00-9:20			6
33	14:50-16:10	13:20-14:40				2
34				14:50-16:10		7
35	8:00-9:20	11:00-12:20				2
36	14:50-16:10				13:20-14:40	4
37	16:20-17:40	14:50-16:10				7

Figure 2. The most favoreable Pareto solution obtained by TOPSIS method.

7. Conclusion and future work

In this paper, a multi objective 0-1 programming model was presented. To make the model more real, different constraints were took into account in our study. These constraints were related to the availability and eligibility of instructors and classes, legal constraints, not overlapping the courses of instructors in a day, not overlapping the primary courses related to the students who enter the university in the same semester, and competency between the timeslots and the courses assigned them. The objectives were to maximize the preference level of instructors and minimize the working days of ones to teach. To evaluate the performance of the proposed model, a real case study was provided. The model was coded in GAMS software and solved by AECM for the case study. Then the TOPSIS method was used to select the most favorable solution among the non_d0minated solutions. For future research, considering other challenges (e.g. disruption and uncertainty) in designing the course timetable, and developing efficient meta-heuristics to address these challenges are suggested.

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