International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 6, Issue 2, February 2017 ISSN 2319 - 4847

Assigning schedules in the industrial engineering program at the Universidad Del Atlántico using linear programming

Adel Mendoza Mendoza[1], Ana Jiménez Rojas[2] Sharon Hernández Escamilla[3]

[1]Department of Industrial Engineering, Universidad del Atlántico

[2]Department of Industrial Engineering, Universidad del Atlántico

[3]Department of Industrial Engineering, Universidad del Atlántico

ABSTRACT

The timetabling problems happen frequently and are easy to find in educational institutions (from schools to universities); from operations research point of view such problems are classified under the timetabling or scheduling area. This research will seek to create a model to assign schedules in the industrial engineering program at the Universidad Del Atlántico; using linear programming to achieved a computerized assigning model for a specified period of time in the program, that can be modified by just making changes in the input parameters. This assignment represents an advance in the organization of times within the university and offers the possibility to optimize the distribution of resources by minimizing the time taken to reach a final schedule.

Keywords:linear programing;university course timetabling; classroom assignment

1. INTRODUCTION

The timetabling problems happen frequently , and involve the generation of specific tasks in a specific time, subject to certain conditions [1] this situations are easy to find in educational institutions (from schools to universities), from the point of view of operations research these problems are classified in the area known as timetabling or scheduling [2]..
Scheduling seeks to set up a planning horizon to assign to each course a classroom and a specific time block; This allocation is made considering the needs and restrictions that may occur due to the preferences of teachers, availability of classrooms, policies of the institution and the educational system [1] .
Usually, programming must be done for a large amount of courses and classrooms, making it unfeasible a totally manual resolution that achieves all the conditions set, furthermore involves a big use of hours of work and personal but with the use and advancement of technology is easier to find an optimal solution. The classification of educational timetabling include: scheduling assessments and tests, class schedules for schools and scheduling for institutions of higher education or universities (University course timetabling) [3].
Problems related to University Course Timetabling have been widely discussed in the literature from different perspectives, including taboo search[4], integer programming models [5] [6] [7] and optimization models (LP) [7] [8] [9] [10] [11], these problems can be classified according to the type of educational institution (schools or universities) and the type of event programming, classes or assessments [2].
Scheduling classes at colleges or universities are very different problems in practice [12]; for the case of linear programming models, these have been considerably studied and used to solve common problems of assignment and optimization [13]. It can be seen that in the case of the Universidad Del Atlántico the allocation model will try to make the course timetabling using LP with a Xijklmn type variable, where each subscript corresponds to each of the linked factors to consider for the efficient resolution of the situation in question.
This research has sought a model that allows the assignment of classrooms and class time efficiently, according to program requirements, faculty and university. To solve the model, the software used will be LINGO 10®.

2. PROBLEM DESCRIPTION

The program of industrial engineering from the Universidad Del Atlántico consists of 10 semesters, in each semester there are two groups of students who must meet specific academic load, assigned to a 25 rooms building, 3 of which are computer rooms and 2 are multi-purpose laboratories.

Each group can receive 6 hours per day in one day. A number of teachers are assigned for each subject, which can give a maximum of 4 hours per day and cannot be consecutive.
There are two types of teachers, tenured and temporary. The tenured teachers must have a minimum academic load of 15 hours per week and a maximum of 20, while the temporary can meet up to 10 hours per week. Teachers who give the same subject must have a shared and uniform load.
Until now, assigning the schedules is responsibility of a group of trained people. The timetable register for a semester is used as the base for programming the next, and it is not updated unless there are changes in the preferences of teachers or modifications to the curriculum. This mapping method has drawbacks usually associated with crossing classrooms, so, finding a model to assign schedules is a current need for the program.

3. METHODOLOGY

The used methodology is the formulation of a linear programming model whose variables are formed by linked elements: subject, semester to which the subject belongs to, group of students, type of classroom, teacher and day; there are two teachers per subject; the restrictions or requirements the model has, can be classified as three types: Restrictions on the type of teacher, restrictions on the type of room and allowed hours restrictions.
Restrictions on the type of teacher:
1. The temporary teachers cannot dictate more than 10 hours per week
2. The tenured teachers cannot dictate less than 15 and more than 20 hours a week.

Restrictions on the type of room:
1. Total number of rooms allocated may not exceed 25 rooms.
2. The amount of rooms for regular classes cannot exceed 20 rooms.
3. The number of multi-purpose laboratories used cannot be greater than 2.
4. The amount of computer rooms used cannot be greater than 3.

Restrictions on number of hours allowed:
1. Each group can receive a maximum of 6 hours per day.
2. You cannot give more than 4 hours straight of the same subject by the same teacher.
3. Each subject has a number of weekly hours assigned.

To solve the model, we used the amount and types of professors, amount and types of rooms and the amount of class groups available for the 2013 academic year in the program. The model proposed was solved using the software named LINGO 10.

The mathematical model for the scheduling problem uses the following decision variables:

$$X_{ijklmn=1}$$

$X_{ijklmn=1}$ If the class *i* of semester *j* for class group *k* given in room *l* by professor *m* on day *n* is assign to the final schedule.
For i = 1… 72; j = 1… 10; k= 1, 2; L= 1… 3; M = 1… 40; N = 1… 5.

Therefore each variable X_{ijklmn} has binary behavior (0 – It's not assigned & 1 – It is assigned).

In this case the problem question is: should the class "*i*" be assigned to the final schedule?

At the end, a minimization model that can be adapted to any situation, with the following approach, is obtained:

Minimize $= \sum_{i=1}^{72}\sum_{j=1}^{10}\sum_{K=1}^{2}\sum_{L=1}^{3}\sum_{M=1}^{40}\sum_{N=1}^{5} X_{ijklmn}$ Objective function (1)
Subject to:
$\sum_{i=1}^{72}\sum_{j=j}^{j}\sum_{K=K}^{K}\sum_{L=1}^{3}\sum_{M=1}^{40}\sum_{N=n}^{n} X_{ijklmn} \leq 6$ Restriction of hours per day(2)
$\sum_{i=i}^{i}\sum_{j=1}^{10}\sum_{K=k}^{k}\sum_{L=1}^{3}\sum_{M=1}^{40}\sum_{N=1}^{5} X_{ijklmn} = \#\, weeklyhours$ Weekly hour's restriction(3)
$\sum_{i=1}^{72}\sum_{j=1}^{10}\sum_{K=1}^{2}\sum_{L=l}^{l}\sum_{M=1}^{40}\sum_{N=n}^{n} X_{ijklmn} \leq \#\, Available\ rooms$ Room restriction (4)
$\sum_{i=1}^{72}\sum_{j=1}^{10}\sum_{K=1}^{2}\sum_{L=1}^{3}\sum_{M=m}^{m}\sum_{N=1}^{5} X_{ijklmn} \leq \#\, weeky\ hours\ per\ profesor$ Hours of each teacher (5)

$$X_{ijklmn} = \begin{cases} 1 \\ 0 \end{cases}$$

The first set of restrictions indicates that the maximum amount of hours that any student can spent in class must be less or equal to six (6) hours per day. The second ones ensure, that the amount of weekly hours seen of each class matches to the amount of hours that, according to the syllabus, must be seen, this restriction should be repeated for each one of the classes i.

The third constraint allows to adjust the model to the physical environment available, in this scenario there are 20 classrooms type K = 1 vacant along with 2 type k = 2 and 3 of type k = 3, for a grand total of 25 rooms that can be used. For which it should be repeated considering which topic *i* occurs in every type of room. The fourth restriction ensures that every professor has the right amount of hours, meeting the upper and lower limits, whereas the last restraint indicates that the variable has binary behavior.

Significantly, each constraint is modified on the subscripts marked with letters, so that the number of repetitions depends on the situation to fit. For this scenario, 1440 variables and 321 constraints are obtained.

As can be seen, the development of a scheduling model is not a simple task. While solving the model all the variables must be satisfied, since the basic concept behind this process is that each class i is assigned for every class group, and so essentially that all mentioned variables has to be fulfilled. The model introduced earlier allows to adjust a schedule for each semester in the same academic program, considering the physical setting, the amount of daily and weekly hours, the quantity of professors (and their academic load) and the number of subjects that each professor dictates.

Finally, data were entered into the Software LINGO to work with the objective function and constraints, and get the optimal scheduling plan.

During the development of which and taking into account the restriction of such software, it was decided to use the most basic modeling language, to subtract, add, modify or isolate any of the variables, without the need to modify the entire model.

4. OBTAINED RESULTS

In this way, the optimal schedule for each semester was obtained. As adjacent results to this solution, the use plans for each classroom and the occupancy rate were also acquired.

Table No 1. Optimum Schedule: First Semester

		DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
FIRST SEMESTER	1 TERM	X2 1 1 1 3 1	X1 1 1 1 1 2	X1 1 1 1 1 3		X1 1 1 1 1 5
	2 TERM	X2 1 1 1 4 1	X1 1 1 1 2 2	X1 1 1 1 2 3		X4 1 1 2 5 5
	3 TERM	X4 1 1 2 6 1	X2 1 1 1 3 2	X3 1 1 3 3 3		X5 1 1 1 9 5
	4 TERM	X4 1 1 2 5 1	X2 1 1 1 4 2	X3 1 1 3 4 3		
	5 TERM	X5 1 1 1 9 1				
	6 TERM	X5 1 1 1 10 1				

Table No 2. Use plan for classroom 1A

	DAY 1	DAY 2	DAY 3	DAY 4	DAY 5
1 TERM	MAT 2	MAT 1	MAT 1	MAT 34	MAT 1
2 TERM	MAT 2	MAT 1	MAT 1	MAT 34	MAT 42
3 TERM	MAT 10	MAT 2	MAT 3		MAT 5
4 TERM	MAT 10	MAT 2	MAT 3		
5 TERM	MAT 5		MAT 20		
6 TERM	MAT 5		MAT 20		

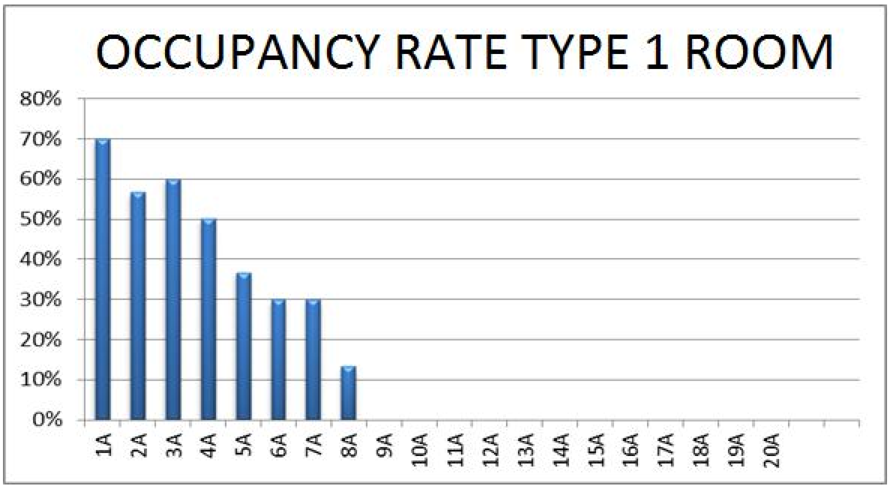

Figure 1. Occupancy rate type 1 room

The coding that was used to identify each subject facilitates the use of resources, given that it specifies, to what type of classroom it has to be assigned to, whom is taking that class (semester & group) and which teacher is responsible for it. With this weekly plan it is easy to see which classes are being worked in each classroom and modify it if needed.

Finally, and as seen in Figure 1, the occupancy weekly rate for each schoolroom is obtained. This allows to assign any extra activities and/or modify the use plan in adverse situations, maintenance, repairs or any other need. With this, it is possible to keep track of changes in the occupation each semester to detect the need to expand resources, expand the number of groups in each subject and generally manage the academic plan.
As stated before, this proposal resolves the problematic described, and at the same time, it can be used as the base for other situations and surroundings.

5. CONCLUSIONS

Assigning a schedule model for the program of Industrial Engineering at the Universidad del Atlántico has been resolved, is clear that the solution found is optimal and feasible for each semester and the computational time and the quality of the solution obtained are reasonable.

As the graphics can show, the classrooms are not entirely used; this means that can be used for other purposes, as classes in another program of the university or any other function.

If the reader's objective is to solve a complete model that includes all the syllabus it’s important to consider the software’s capability since some versions of LINGO have a lower capacity than needed to solve this problem as a whole model.

References

[1]. E. Burke, Recent research directions in automated timetabling, European Journal of Operational Research, 140:266–280, 2002.

[2]. R. Hernández, J. Miranda J, and Rey P. Programación de Horarios de Clases y Asignación de Salas para la Facultad de Ingeniería de la Universidad Diego Portales Mediante un Enfoque de Programación Entera. Review Ingeniería de Sistemas, 22:124-141, 2008.

[3]. A. Schaerf. A survey of automated timetabling. Artificial Intelligence Review, 13:87–127, 1999.

[4]. G.M White and Zhang J. Generating Complete University Timetables by Combining Tabu Search and Constraint Logic, Practice and Theory of Automated Timetabling II, SpringerVerlag, Computer Science, 1408:187-198, 1998.

[5]. A. Tripathy. School timetabling - A case in large binary integer linear programming. Management Science, 30(12):1473-1489, 1984.

[6]. M. A. Bakır and C. Aksop. A 0-1 integer programming approach to a university timetabling problem. Hacettepe Journal of Mathematics and Statistics, 37 (1): 41 – 55, 2008.

[7]. S. Daskalaki, T. Birbas and E. Housos. An integer programming formulation for a case study in university timetabling. European Journal of Operational Research, 153: 117–135, 2004.

[8]. J. Nakasuwan, P. Srithip and S. Komolavanij. Class scheduling optimization. ThammasaItn t. J. Sc.Tech. 4(2):88-98, 1999.

[9]. Stallaert, J. (1997), Automated timetabling improves course scheduling at UCLA, Interfaces, 27, 67–81, (1997).

[10]. J. Miranda and P. Rey. Un modelo de programación entera basado en patrones para la asignación de salas de clases para una facultad de medicina. Proceedings of the CLAIO/SBPO 2012, 1114-1124. Río de Janeiro. 2012.

[11]. M. Heredia. Modelo de programación lineal entera para la generación de horarios de clase en la universidad. Undergraduate thesis. Escuela Politécnica Nacional, Quito, 2011.

[12]. A. Saldaña, C. Olivo, L. Pradenas. Modelos de programación entera para un problema de programación de horarios para universidades. Ingeniare. Revista chilena de ingeniería, 15(3):245-259, 2007.

[13]. S. Hahn-Goldberg. Defining, Modeling, and Solving a Real University Course Timetabling Problem. Degree thesis of Masters of Applied Science, University of Toronto, Toronto, pp. 7-9, 2007.