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Solving a University Course Timetabling Problem Based on AACSB Policies

Nancy M. Arratia-Martinez *,†, Paulina A. Avila-Torres † and Juana C. Trujillo-Reyes †

Department of Business Administration, Universidad de las Américas Puebla/Ex-Hacienda Santa Catarina Mártir, San Andres Cholula, Puebla 72810, Mexico; paulina.avila@udlap.mx (P.A.A.-T.); juanac.trujillo@udlap.mx (J.C.T.-R.)
* Correspondence: nancy.arratia@udlap.mx
† These authors contributed equally to this work.

Abstract: The purpose of this research is to solve the university course timetabling problem (UCTP) that consists of designing a schedule of the courses to be offered in one academic period based on students' demand, faculty composition and institutional constraints considering the policies established in the standards of the Association to Advance Collegiate Schools of Business (AACSB) accreditation. These standards involve faculty assignment with high level credentials that have to be fulfilled for business schools on the road to seek recognition and differentiation while providing exceptional learning. A new mathematical model for UCTP is proposed. The model allows the course-section-professor-time slot to be assigned for an academic department strategically using the faculty workload, course overload, and the fulfillment of the AACSB criteria. Further, the courses that will require new hires are classified according to the faculty qualifications stablished by AACSB. A real-world case is described and solved to show the efficiency of the proposed model. An analysis of different strategies derived from institutional policies that impacts the resulting timetabling is also presented. The results show the course overload could be a valuable strategy for helping mitigate the total of new hires needed. The proposed model allows to create the course at the same time the AACSB standards are met.

Keywords: timetabling problem; course university timetabling problem; AACSB standards; integer linear programming

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1. Introduction

Timetabling is the process of building a timetable while satisfying several constraints. The timetabling problem has many applications such as educational and transportation issues for employees and others [1]. This research is focused on the university course timetabling problem, a problem that has been extensively studied [2]. The University Course Timetabling Problem (UCTP) consists of supplying a schedule of the courses to be offered in one academic period based on students enrolled and constraints established by the university. A course timetabling usually involves the allocation of resources (teachers, students, classrooms, etc.) and time slots to each given meeting (lectures, seminars, etc.) while satisfying constraints [3].

The UCTP has three stages: (i) faculty course assignment optimization, (ii) faculty course scheduling optimizations and (iii) faculty room assignment optimization [4], there are many constraints to be considered and they are usually divided into two categories: (i) hard constraints, these constraints must be satisfied in order to produce a feasible timetable and (ii) soft constraints, these constraints are desirable but not absolutely essential [2].

UCTP is considered one of the most interesting problems faced by universities [5] but some of them are still constructing timetables by hand [6] with the assistance of simple office applications like spreadsheets. This is a very difficult task given the many restrictions to be satisfied [3]. The automation of timetabling problems is a task that saves a lot of work and time for institutions, it also provides optimal solutions by improving the quality of education and services [5]. The educational timetabling problem has been formulated in many different ways and has been addressed using several analytic or heuristic approaches. However, it is difficult to implement the same approach to a problem because each institution has different characteristics and constraints or limitations [7].

There are some authors that consider preferences of the faculty in different areas. Such is the case of the method proposed by Immonen and Putkonen [8] where they build a timetable satisfying pre-requisite knowledge and specific preferences for faculty. Also Tavakoli et al. [9] say one subject can be taught by many lecturers but the priority must be given to the one with higher qualifications. In [10], authors use a bee colony optimization and consider the preferences of subjects a professor can teach. Another work is the one proposed by Domenech and Lusa [11] in which they propose a mathematical model considering some preferences according to the category of the professor. Al-Yakoob and Sherali [12] developed a mathematical model for assigning faculty members to classes considering their preferences of time as much as possible and the qualifications of the faculty.

Another characteristic considered in the construction of the timetable is the workload of the faculty, for example, in [11] authors propose a mathematical model where they balance the teachers' workload. Authors in [12] present a mathematical model for assigning faculty members to classes considering teaching load and qualifications, the objective of the model is to minimize the dissatisfaction of faculty members. In some cases according to the level of the professor some institutions may establish a number of days a professor can teach in order to give them the opportunity to do work in research, such is the case of the approach made by Chen and Shih [13] where teachers of specific levels can only teach two classes per week and each teacher may not teach more hours than the limit stipulated by the academic department. Further, authors in [10] consider the maximum number of courses a professor can teach, or create a fair course timetable, balancing the interests between faculty [14].

Characteristics like, preferences of different types, workload, among others are important in the construction of timetable for business schools that are accredited by the Association to Advance Collegiate Schools of Business (AACSB) or for those institutions that would like to obtain the accreditation. For the latter, it is important to build the timetable fulfilling the standards established by AACSB. The mathematical model presented by Boronico and Kong [15] determines the full-time faculty (without any decision about the timetable) required according to accreditation guidelines of AACSB for the different campuses and disciplines, this is the reason business schools must now specify their relative emphasis on teaching, intellectual contributions, service, and make explicit commitments to particular types of intellectual contributions [16].

For business schools, it is very important to obtain the AACSB accreditation, specially for those schools outside North America and Europe [17], according to Bajada and Trayler [18], the faculty of a modern business school is expected to be academically qualified (AQ) under AACSB standards. For an institution that would like to receive AACSB accreditation, a certain percentage of the business school faculty must be AQ [17].

AACSB is an important influence on many business schools, that is the reason the accredited business schools are expected to have highly qualified faculty members to complete the course timetabling, but the number of faculty available to fill open positions is not sufficient and it is difficult for schools to recruit and retain the qualified faculty [19].

AACSB is becoming more important for business schools and fulfilling the standards is determinant to achieve the accreditation or re-accreditation. This implies universities need to accomplish the percentages of professors in every category and the construction of the timetable is directly related to that standard.

In the reviewed literature, we did not find any other paper that involves the timetabling problem with all the characteristics addressed here and the AACSB standards. This research is focused in the construction of a university course timetable for a business school considering mainly the preferences and qualifications of faculty, teaching load and the category of the professors in order to fulfill the percentages of the qualification standards established by the AACSB. The output of the model will be the assignment of professor to subject and time slot, also the number of professors that have to be hired in order to achieve the percentages indicated by the standard of the AACSB.

The papers found in the reviewed literature have some similarities with the proposed model. For example, authors like Immonen and Putkonen [8] and Al-Yakoob and Sherali [12] include in their construction of timetabling the qualification of professors. The category of professors is considered by Domenech and Lusa [11] and Chen and Shih [13]. Another similarity is the consideration of maximum number of courses, a characteristic taken into account by Ojha and Sahoo [10]. But our proposal has some differences with the papers found in literature, for example, we do not consider the balance of workload whereas Domenech and Lusa [11] and Al-Yakoob and Sherali [12] include this characteristic and the models proposed by them. One of the decision made by our proposed model is whether to give or not work overload to professors, characteristic not found in any other model. Boronico and Kong [15] take into account the standards of AACSB but they do not construct the timetable. Their model indicates the number of professors needed in each campus is order to comply the percentages of each category in the AACSB standards. To sum it up, any other paper that involves the timetabling problem with all the characteristics addressed here and the AACSB standards was not found.

The article is organized as followed, the rest of the Section 1 provides a description of the AACSB accreditation as well as the faculty standard; Section 2 describes on detail the context of the case study; Section 3 presents the proposed mathematical model; Section 4 presents the case information; Section 5 presents a discussion of the results; Section 6 presents the conclusions of the present work.

AACSB Accreditation and Standards

A challenge facing economic programs in business schools is that of aligning programs to be consistent with the assessment expectations for the AACSB accreditation [20]. Business school accreditation is a way for business schools to differentiate their brand and demonstrate the highest standard of achievement [21]. The AACSB is the most important institution responsible of accrediting business schools around the world. The AACSB was founded in 1916 and established the first standards for programs in business administration in 1919. Nowadays, there are 874 business institutions in 56 countries that have earned the AACSB accreditation [22].

A business school has to follow the next process in order to apply for the AACSB Accreditation: first, the business school must establish its membership and eligibility for accreditation. During the initial accreditation process, the school is evaluated based on the AACSB accreditation standards. After earning the AACSB accreditation, the business school is periodically evaluated to continue its accreditation [22].

The nine standards that every business school have to achieve are divided into three categories: (1) Strategic management and innovation, (2) Learner success and (3) Thought leadership, engagement and societal impact learning and teaching. Standard three declares that the school should maintain and strategically deploy a sufficient number of participating (P) and supporting (S) faculty. A participating faculty actively takes part in the activities of the school besides teaching responsibilities. A supporting faculty is more dedicated to teaching responsibilities; she/he does not normally participate in the intellectual or operational life of the school [22].

According to the AACSB, the faculty is classified as follows: Scholarly Academic (SA), Practice Academic (PA), Scholarly Practitioner (SP), or Instructional Practitioner (IP). Faculty members who do not meet the definitions of any of these categories are classified as Additional Faculty (A).

- Scholarly Academics (SA) are faculty who have normally attained a terminal degree in a field related to the area of teaching and who sustain currency and relevance through scholarship and related activities.

- Practice Academics (PA) are faculty who have normally attained a terminal degree in a field related to teaching and who sustain currency and relevance through professional engagement, interaction, and relevant activities.
- Scholarly Practitioners (SP) are faculty who have normally attained a master's degree related to the field of teaching; have professional experience and produce scholarship related to their professional background and experience.
- Instructional Practitioners (IP) are faculty who have normally attained a master's degree related to the field of teaching and who have professional experience and continue their engagement related to their professional background and experience.
- Additional Faculty (A) are faculty who do not meet the expectations of the school as SA, PA, SP, or IP because the individual faculty member's initial preparation and/or on-going engagement activities are not aligned with the school's criteria.

In the first case (SA), they should have actual and relevancy research and activities linked to the same field of teaching. In the second case (PA), the teachers should be working in relevant professional positions also related to the field of teaching. The faculty classified as SA and PA must have a doctorate degree.

On the other hand, SP and IP have a master's degree related to a teaching field and have significant professional experience at the same field they are teaching. The difference in this case is that SP sustain research associated to the area of their professional background and experience where they teach, and IP show relevancy and engagement through their professional experience related to their teaching field.

For more information on the above categories, please refer to the AACSB manual.

The standards provide guidance about the criteria the school should develop. The criteria applied to faculty is the following:

- At least 60% of faculty should be participating. Faculty sufficiency related to teaching is measured through a teaching productivity metric (a particular institutional metric, e.g., contact-hours, course-hours, courses) and the overall should be at least 60% for the participating components.
- Percentage of time devoted to mission for each faculty qualification group:
  - Scholarly Academics $\geq$ 40%.
  - Scholarly Academics + Practice Academics + Scholarly Practitioners $\geq$ 60%.
  - Scholarly Academics + Practice Academics + Scholarly Practitioners + Instructional Practitioners $\geq$ 90%.
  - Additional Faculty less than 10%.

  Normally, full-time professors spend 100% of their time devoted to the mission and an adequate and rational manner to assess the percentage of time devoted to the mission should be establish for part-time faculty [23].

2. Context of the Problem

The Business School is composed of seven departments. In a fall 2020 semester the school offered 345 courses in total for 7750 registered students. In the past, the 24% of the courses of the entire Business School corresponded to the academic department under study. This department can be considered one of the biggest in the business school. It offers 9 service courses to the other departments at school and also to other six bachelors degree of others schools.

Some years ago, the university started the process of achieving the AACSB accreditation, now the construction of the timetable has to consider the characteristics of the school and it has to fulfill the requirements of standard three of the AACSB. The current process is as follows:

1. The dean's office informs the academic department the number of students demanded by each course.

2. The academic department defines the number of groups (sections) for the same course to be offered according to the maximum number of students per course allowed by the university.
3. A first draft of the timetable is created manually, trying to satisfy the percentages of each category in the AACSB standard and other requirements.
4. If the academic department notices a lower percentage than the required, then they have to recruit a professor of specific category.
5. The academic department confirms the assignment with each professor and some changes could be made.
6. Once the timetable is confirmed, it is sent to dean's office where the assignment of classrooms is performed.
7. Finally, the academic department proceeds to register the course timetable in the university's system and to publish it on the official website.

In this case, student curricula consists of eight semesters and fifty courses that are divided into general education courses, basic/initial disciplinary education courses, and disciplinary courses. In a specific academic period there are students enrolled in each of the level (from first to eighth semesters), so it is needed to program all the courses by period but just the disciplinary courses are in charge of the academic department.

The requirements of the administration are:

- There are two schemes of time slots for the academic department courses: scheme A) three sessions of one hour on Monday, Wednesday and Friday and, scheme B) two sessions of one hour and thirty minutes for Tuesday and Thursday.
- The first class of the day starts at 7:00 a.m. and the last one starts at 7:00 p.m.
- The courses that belong to the same semester in the curricula are assigned in different time slots.
- Semester courses from 1st to 4th are assigned to start in the morning (07:00 to 14:00 h.), and from the 5th to 8th in the afternoon (13:00 to 20:00 h, and 7:00 a.m.). Some courses will need to be scheduled at additional times due to their high demand.
- The course assignment for a professor is made by considering her/his knowledge area.
- The number of courses to be assigned to full-time professors is well known and it depends of her/his profile (researcher or manager position).
- Further, overload is allowed, when a course is assigned to a professor additionally to her/his official basic workload (authorized by the university).
- It is not desirable to assign more than two courses to part-time professors.
- When the total of courses to be scheduled exceeds the actual capacity (using course load and overload), then new hires should be considered.

3. Mathematical Formulation

When a department belongs to a school which wants to be accredited by high standards such as AACSB, and plays a fundamental role scheduling a large number of courses, it requires having mechanisms that facilitate decision-making to assign courses to the right teachers. Therefore, the mathematical formulations offer opportunities not only for assigning a large number of sections, but also for accomplishing the requirements of faculty qualifications.

The mathematical model proposed allows to determine the assignation of course-section-professor-time slot using the actual capacity. In case, it is not possible to schedule all courses, the remaining courses will be assigned to one faculty member category based on AACSB faculty qualifications policies and then the new hires can be established. Also the concept of course overload is contemplated.

Sets

C	Set of courses, index $i \in C$.
P	Set of professors, index $j \in P$.
$P_{full-time}$	Set of full-time professors, index $j \in P_{full-time}$, $P_{full-time} \subset P$.
$P_{part-time}$	Set of part-time professors, index $j \in P_{part-time}$, $P_{part-time} \subset P$.
T	Set of semesters, index $t \in T$.
B	Set of time slots, index $k \in B$.
B_t	Subset of time slots that are allowed to schedule courses belonging the semester $t \in T$.
C_j	Set of courses that the professor j can teach according with her/his knowledge area, $C_j \subset C$.
S_i	Set of sections needed to be schedule for the course i.
H_1	Set of faculty qualification categories, index $p \in H_1 = \{SA, PA, SP, IP, A\}$.
H_2	Set of categories for faculty composition based on the level of professors involvement, index $q \in H_2 = \{\text{participating, supporting}\}$.
H_3	Set of profiles of new hires based on the minimum academic profiles needed in order to allocate all the courses, index $r \in H_3$.
CH_r	Set of courses that can be taught by a professor with academic profile $r \in H_3$.
P^*	Set of professors with faculty composition category: participating.

Parameters

h_i	Semester to which the course i belongs.
m_j^{max}	Maximum number of courses to be assigned to professor j.
m_j^{min}	Minimum number of courses to be assigned to professor j.
c_j^{max}	Maximum number of course overload allowed for professor j.
α_j	Qualification of the professor j, $\alpha_j \in H_1$.
u	Percentage of faculty time spent dedicated to the mission per course for supporting faculty.
v	Percentage of faculty time spent dedicated to the mission per participating faculty (in some cases it could be naturally 100%).

The decision variables in our model are denoted as follows:

$$x_{ijkl} = \begin{cases} 1 & \text{if, the course } i \text{ is assigned to professor } j \text{ in time slot } k \text{ in section } l \\ 0 & \text{otherwise.} \end{cases}$$

$\sigma_j =$ Number of courses assigned to professor j without exceeding the number of courses allowed according to her/his academic profile.

$\sigma_j^+ =$ Number of additional courses assigned to full-time professors as course overload.

$w_i =$ Quantity of sections of the course i without assignation of schedule and professor.

$y_{pqr} =$ Quantity of course sections that weren't programmed due to the lack of enough teacher staff, also to be programmed for new candidate professors with faculty qualification category $p \in H_1$ and with faculty composition category based on the level involvement $q \in H_2$ and an academic profile $r \in H_3$.

$z_{pqr} =$ Auxiliary variables denoting the quantity of minimum candidates to professors to be hired with faculty qualification category $p \in H_1$, with faculty composition category based on the level involvement $q \in H_2$ and an academic profile $r \in H_3$.

The variables y_{pqr} individually help to know how many courses without schedule require a specific professor profile (new hire) to maintain the adequate levels of the AACSB standards.

The objective function has to be established in accordance with the institution's strategy, in this paper three possible objectives are stated. Naturally, it is desirable to minimize the total of courses without schedule (that need to be assigned to new hires) (Equation (1)).

$$\text{minimize} \sum_{p \in H_1} \sum_{q \in H_2} \sum_{r \in H_3} y_{pqr} \tag{1}$$

Other objective function based on a policy is to minimize the aggregation of courses without schedule and the course overload of professors, this is described in expression (2).

$$\text{minimize} \sum_{p \in H_1} \sum_{q \in H_2} \sum_{r \in H_3} y_{pqr} + \sum_{j \in P} \sigma_j^+ \tag{2}$$

Further, in expression (3) the total number of new hires is minimized since the objective in expression (1) does not differentiate courses that can be assigned to different academic profiles. The value of z_{pqr} is estimated in (20).

$$\text{minimize} \sum_{p \in H_1} \sum_{q \in H_2} \sum_{r \in H_3} z_{pqr} \tag{3}$$

Since all sections should be assigned whenever possible, the group of constraints (4) guarantees that all course sections will be scheduled only if there is enough capacity (i.e., $w_i = 0$), otherwise, the variable w_i will take a value greater than zero ($w_i > 0$).

$$\sum_{j \in P} \sum_{k \in B} \sum_{l \in S_i} X_{ijkl} + w_i = \mid S_i \mid \quad \forall i \in C \tag{4}$$

where $\mid S_i \mid$ denotes the cardinality of the set S_i.

The constraint group (5) states that each course section should be assigned just once.

$$\sum_{j \in P} \sum_{k \in B} X_{ijkl} \leq 1 \quad \forall i \in C, \forall l \in S_i \tag{5}$$

Course sections without a schedule and teacher assignment will result in new teacher hires with an AACSB faculty qualification category $p \in H_1$, a category of faculty composition based on the level of involvement $q \in H_2$ and with an academic profile $r \in H_3$. In constraint group (6) it is stated that the number of course sections without schedule that can be assigned to a candidate professor with an academic profile $r \in H_3$ should be equal to the number of courses assigned to new professors with a profile in each set of categories (H_1 and H_2). It allows to balance and to relate course sections with faculty profiles.

$$\sum_{p \in H_1} \sum_{q \in H_2} y_{pqr} = \sum_{i \in CH_r} w_i \quad r \in H_3 \tag{6}$$

All professors have a maximum and a minimum number of course sections to be assigned, this is restricted by (7) and (8). Commonly, for full-time professors this quantity represents the mandatory number of courses to be assigned, in that case $m_j^{max} = m_j^{min}$.

$$\sigma_j \leq m_j^{max} \quad \forall j \in P \tag{7}$$

$$\sigma_j \geq m_j^{min} \quad \forall j \in P \tag{8}$$

This model contemplates the concept of restricted course overload in order to consider to teach more than the maximum courses allowed for each professor. The number of assigned course sections of each professor is equal to the sum of the course load plus the course overload assigned, as it is shown in the group of constraints (9).

$$\sum_{i \in C} \sum_{k \in B} \sum_{l \in S_i} x_{ijkl} = \sigma_j + \sigma_j^+ \quad \forall j \in P \tag{9}$$

When the course overload does not apply for all professors or for part-time professors, it can be easily restricted. The constraint group (10) states the maximum number for professor j course overload.

$$\sigma_j^+ \leq c_j^{max} \quad \forall j \in P \tag{10}$$

Regarding the schedule, in (11) it is stated that all courses that belong to a same semester must be assigned to different time slots.

$$\sum_{i \in \{C|h_i = t\}} \sum_{j \in P} \sum_{l \in S_i} X_{ijkl} \leq 1 \quad \forall t \in T, \forall k \in B \tag{11}$$

As it was mention in the previous section, the courses belonging to semester t should be scheduled just in the allowed time slots (the subset B_t), as it is shown in constraint group (12).

$$\sum_{j \in P} \sum_{k \notin B_t} X_{ijkl} \leq 0 \quad \forall t \in T, \forall i \in \{C|h_i = t\}, \forall l \in S_i \tag{12}$$

The constraint group (13) ensures that all professors will be assigned their courses in different time slots. It means that, there will not be any overlap in the schedule of professors.

$$\sum_{i \in C} \sum_{l \in S_i} X_{ijkl} \leq 1 \quad \forall j \in P, \forall k \in B \tag{13}$$

The courses assigned to the professors will be according to their credentials (14). Previously, a list of courses that a professor can teach according to her/his expertise area was created.

$$X_{ijkl} \leq 0 \quad \forall j \in P, \forall i \notin C_j, \forall l \in S_i, \forall k \in B \tag{14}$$

In some cases, full-time professors need to have a free day scheme in the afternoon allowing to teach at graduate programs as expressed in constraints (15)–(19). The set of time slots in conflict is $B' \subset B$ for days scheme A, and $B'' \subset B$ for days scheme B. The auxiliary binary variables A_j and B_j denote if a professor j is free in the time slots to teach at the graduate program in the scheme A and scheme B, respectively.

$$A_j + B_j \leq 1 \quad \forall j \in P_{full-time} \tag{15}$$

$$A_j \cdot \sigma_j \geq \sum_{i \in C} \sum_{l \in S_i} \sum_{k \in B'} X_{ijkl} \quad \forall j \in P_{full-time} \tag{16}$$

$$A_j \leq \sum_{i \in C} \sum_{l \in S_i} \sum_{k \subseteq B'} X_{ijkl} \quad \forall j \in P_{full-time} \tag{17}$$

$$B_j \cdot \sigma_i \geq \sum_{i \in C} \sum_{l \in S_i} \sum_{k \in B''} X_{ijkl} \quad \forall j \in P_{full-time} \tag{18}$$

$$B_j \leq \sum_{i \in C} \sum_{l \in S_i} \sum_{k \subseteq B''} X_{ijkl} \quad \forall j \in P_{full-time} \tag{19}$$

In (20) the number of professors needed for profile is calculated.

$$z_{pqr} \geq \frac{y_{pqr}}{M}, \quad \forall p \in H_1, \forall q \in H_2, \forall r \in H_3 \tag{20}$$

where M denotes the maximum course load for a new professor.

To establish the criteria and policies for faculty based on AACSB standards the constraints (21)–(25) were incorporated.

Based on the metric selected (number of courses), we restricted that 60% of courses have to be imparted by participating faculty, as it is shown in constraint (21).

$$\sum_{j \in P^*} \left(\sigma_j + \sigma_j^+\right) + \sum_{p \in H_1} \sum_{r \in H_3} y_{pqr} \geq 0.60 \sum_{i \in C} |\ S_i\ |, \quad q = \text{participating} \tag{21}$$

The total time dedicated to mission for each AACSB faculty qualification category is calculated in (22). The constraints are defined with $q_1 =$ participating, $q_2 =$ supporting and, $\forall p \in H_1$.

$$ded_p = u\left(\sum_{j\in P-P^*|\alpha_j=p}(\sigma_j+\sigma_j^+)+\sum_{r\in H_3} y_{pq_2r}\right)+v\left(|P^*|+\sum_{r\in H_3} z_{pq_1r}\right) \tag{22}$$

Then, the time dedication to the mission of all faculty and courses with a hiring profile is restricted in (23)–(25). Different metrics can be applied according to the best structure for the institution. Here, the percentage of total time spend dedicated to the mission differentiating the percentage of participating faculty and supporting faculty is calculated.

$$ded_{SA} \geq 0.4 \sum_{p\in H_1} ded_p \tag{23}$$

$$ded_{SA}+ded_{PA}+ded_{SP} \geq 0.6 \sum_{p\in H_1} ded_p \tag{24}$$

$$ded_{SA}+ded_{PA}+ded_{SP}+ded_{IP} \geq 0.9 \sum_{p\in H_1} ded_p \tag{25}$$

Further, additional constraints to limit the number of new hires can be added for some determined profile. In constraint group (26) the latter condition is added.

$$z_{pqr} \leq a_{pqr} \tag{26}$$

where a_{pqr} are the maximum number of hires allowed by faculty qualification category p, with faculty composition category based on the level involvement $q \in H_2$ and an academic profile $r \in H_3$.

Finally, the no-negativity constraints are included for the integer variables.

$$w_i \geq 0 \quad \forall i \in C \tag{27}$$

$$y_{pqr}, z_{pqr} \geq 0 \quad \forall p \in H_1, \forall q \in H_2, \forall r \in H_3 \tag{28}$$

$$\sigma_j, \sigma_j^+ \geq 0 \quad \forall j \in P \tag{29}$$

Remarks of the Mathematical Formulation

Here some main remarks about the mathematical formulation are exposed:

- In the proposed mathematical model the variables that allow to define the timetabling are x_{ijkl}, while w_i are the number of sections by course i that could not be programmed with the current faculty. In the Equation (4) is established the relation between these variables.
- Since in the objective functions the y_{pqr} variables are minimized directly or indirectly and the sum of all y_{pqr} and the sum of all w_i variables are equal, then the w_i variables are also minimized in an indirectly form.
- The variables y_{pqr} and z_{pqr} are related in the mathematical model in constraints (20), which allow to determine the number of new hires given the number of courses without schedule for all $p \in H_1$, $q \in H_2$ and $r \in H_3$ categories.
- The values of variables x_{ijkl} impact in the assignations of the variables y_{pqr}, since as was mentioned before, the variables x_{ijkl} and w_i are related, and the variables w_i are related with y_{pqr}, then, the variables x_{ijkl} are related indirectly with the variables y_{pqr}.
- Regarding the latter, the constraints of balancing (21)–(25) are used to ensure compliance with the standard three of AACSB while defining the values for variables y_{pqr}.

- The variables x_{ijkl} and z_{pqr} are related through the relation stablished before about the pairs of variables (x_{ijkl}, w_i) (w_i, y_{pqr}) and (y_{pqr}, z_{pqr}).

4. Case Information

In this section the main information of the case studied corresponding to the fall 2020 academic period is described.

As it is stated in Table 1, in the academic period fall 2020, the academic department was constituted by 28 teachers (17 full-time professors and 11 part-time professors) with different profiles and preferences of courses according to their qualifications. They are classified as six supporting professors and 22 participating, according to the category (explained in the Section 1) the same 28 teachers can be classified as: 12 IP, 12 SA, 2 PA, 1 SP and 1 is classified as A (categories explained in Section 1).

There were 28 courses, each one with a specific number of sections (or groups), in total 82 sections to be scheduled. The course load and the list of possible courses to assign for each professor, are presented in Table 1. To get the solution, the course overload for part-time professors was considered as zero, since this concept is applicable just for full-time faculty.

Table 1. Information of professors.

Professor ID	Max. Courses	Courses	Professor ID	Max. Courses	Courses
P1	2	23	P15	3	27, 15, 10, 11
P2	3	24, 18, 2, 1	P16	2	25
P3	2	20, 8, 16	P17	4	16, 17, 7
P4	3	8, 16	P18	4	9, 16, 4, 6
P5	1	25	P19	4	16, 12
P6	3	25, 14, 21, 11, 3, 10	P20	2	18, 2, 1
P7	2	25, 16	P21	2	8,6
P8	2	11, 15, 2, 10	P22	2	28, 1, 2
P9	2	13, 5, 16, 20	P23	3	23, 12, 8, 7
P10	2	3, 24	P24	3	27, 1, 2
P11	2	26, 24	P25	2	9, 16
P12	2	16	P26	2	15
P13	3	22, 17, 16	P27	3	19, 16
P14	2	25, 3, 10, 11	P28	3	16

The courses are distributed in the follow way:

Semester 1: 16 and 19.
Semester 2: 7 and 9.
Semester 3: 12 and 13.
Semester 4: 6, 8, 10 and 25.
Semester 5: 11, 14 and 18.
Semester 6: 2, 5, 17 and 20.
Semester 7: 1, 4, 15, 21 and 26.
Semester 8: 3, 22, 23, 24, 27 and 28.

Regarding new hires, based on the conditions established by the institution, it is possible to define limits on new hires, according to the categories and profiles established. For this, the constraint group (26) are established with the following limits: zero new hires with profile SA-supporting and for PA-supporting categories, also, zero new hires with profile SP-supporting, IP-supporting and A-supporting. The latter applies for all academic profiles ($r \in H_3$).

The academic profiles are defined through the clusters of courses:

Academic profile 1: courses 10, 11, 12, 15, 20, 26, 27,
Academic profile 2: courses 1, 2, 18, 24,
Academic profile 3: courses 7, 8, 9, 13, 17, 23,
Academic profile 4: courses 3, 14, 25, 26, 27,
Academic profile 5: courses 16, 4, 5, 6, 19, 21, 22, 28.

In this way we assume a determined professor can be related with courses in one specific academic profile by her/his knowledge area.

To calculate the percentage of time dedication to the mission, course-hours for supporting professors (i.e., 7.5% of the time per course) were applied. And, the sum of time dedication to mission is 100% for all participating professors. Finally, since a new hire will be classified as either supporting or participating, for practical purposes we consider a new hire with a participating profile to be full-time and part-time for a supporting profile.

5. Results

In this section the results obtained for the UCTP based on the AACSB policies are presented.

Four strategies were applied to analyze the effects of combining new hiring profiles and course overload for professors through the minimization criteria, whether or not course overload was allowed. The four strategies are:

1. to minimize courses without schedule allowing course overload (base case). This formulation is composed of objective function (1), and constraints (4)–(29).
2. to minimize courses without schedule and zero teaching overload. This formulation is composed of objective function (1), and constraints (4)–(29). To avoid the course overload, in constraint (10), the parameter c_j^{max} is equal zero for all $j \in P$.
3. to minimize courses without schedule and teaching overload. This formulation is composed of objective function (2), and constraints (4)–(29).
4. to minimize hiring profiles (professors). This formulation is composed of objective function (3), and constraints (4)–(29). In this case, course overload is allowed.

The four strategies were solved through the proposed integer programming model implemented with ILOG CPLEX Optimization Studio version 12.8 on a computer with an Intel i7 at 2.5 GHz and 8 Gb of RAM. The solution algorithm used was the classic Branch and bound method. The execution time of the solutions was less than a second (0.58 s. in average) and in all cases the optimality was obtained with a zero value for the solution gap. To access the output of the solver CPLEX of the first strategy, see the Section Data Availability Statement.

5.1. Minimizing the Courses without Schedule Allowing Course Overload, the Base Case

The timetable for the case studied is shown in Figures 1 and 2. First, in Figure 1 we show the assigned courses to each time slot in day scheme A: Monday, Wednesday and Friday (i.e three classes of 1 h per week). The color indicates the semester to which the course belongs. We named each assignation as C#S#P#, where the number contiguous to C is the course ID, then, the number next to the S is the number of section of that course, and finally, the number after P is the professor's ID. As an example, the blue cell in time 07:00-08:00 (C19S1P27) implies that Section 1 of the course with ID19 from the first semester is assigned to professor ID P27 at that time. Naturally, Table 1 with the professors' information shows that professor ID P27 can teach course ID19.

	Days			
Time	Monday, Wednesday, Friday			
07:00-08:00	C19S1P27	C7S1P17	C12S2P19	C8S3P3
	C14S1P6	C26S1P11	C3S6P10	
08:00-09:00	C9S1P18	C25S4P7		
09:00-10:00	C25S1P5			
10:00-11:00	C6S2P21			
11:00-12:00	C25S5P5			
12:00-13:00	C7S2P17	C8S2P23		
13:00-14:00	C16S3P27	C8S4P23	C18S1P20	C1S2P2
	C27S1P15			
14:00-15:00	C9S5P25	C6S1P21	C11S1P14	C2S1P20
	C1S1P24	C28S1P22		
15:00-16:00	C9S4P18	C12S3P19	C25S3P16	C5S1P9
	C15S3P26	C27S2P24		
16:00-17:00	C11S2P8	C2S3P24	C26S2P11	C22S1P13
17:00-18:00	C22S3P13			
18:00-19:00	C18S3P20	C3S2P14		
19:00-20:00	C18S2P2	C3S3P10		

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Figure 1. Timetable for courses in day scheme A: Monday, Wednesday and Friday, three classes of 1 h per week.

	Days			
Time	Tuesday and Thursday			
07:00-08:30	C9S6P18	C12S4P23	C25S2P16	C20S2P3
	C15S1P15	C3S5P10		
08:30-10:00	C16S6P19	C8S5P23		
10:00-11:30	C16S2P17	C12S1P19	C8S6P4	
11:30-13:00	C16S4P12	C9S3P25	C13S1P9	C8S1P4
13:00-14:30	C16S5P3	C9S2P18	C10S1P8	C14S2P6
	C17S1P17	C24S2P2		
14:30-16:00	C16S1P4	C25S6P7	C2S2P8	C21S2P6
	C23S4P1			
16:00-17:30	C20S1P10	C21S1P6	C3S4P14	
17:30-19:00	C2S4P22	C15S2P26	C22S2P13	
19:00-15:00	C17S2P13	C4S4P18	C23S2P1	

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Figure 2. Timetable for courses in day scheme B: Tuesday and Thursday, two classes of 1 h and a half per week.

Figure 2 shows the assigned courses in day scheme B: Tuesday and Thursday classes (i.e., two classes of 1 h and 30 m per week). The same name structure for course assignation was applied.

The timetable obtained has 75 course sections scheduled (40 in Figure 1 and 35 in Figure 2) from the total of 82 needed course sections. Sixty four courses are assigned with basic faculty workload and 11 are overload assigned to full-time professors. The remaining seven non-scheduled course sections have an assigned hiring profile. The corresponding sections are: one section from course ID3, three sections from course ID4, two sections from course ID23, one section of the course ID24.

Figure 3 shows the proportions of the courses scheduled (with basic workload and with course overload) and courses with hiring profiles. It is important to note, that the contemplated assigned professors correspond to the list of active professors in the immediate preceding period, but when the courses' demand increases, it will be necessary to contemplate hiring profiles. In these cases, the solution implies seven non-scheduled courses with hiring profiles.

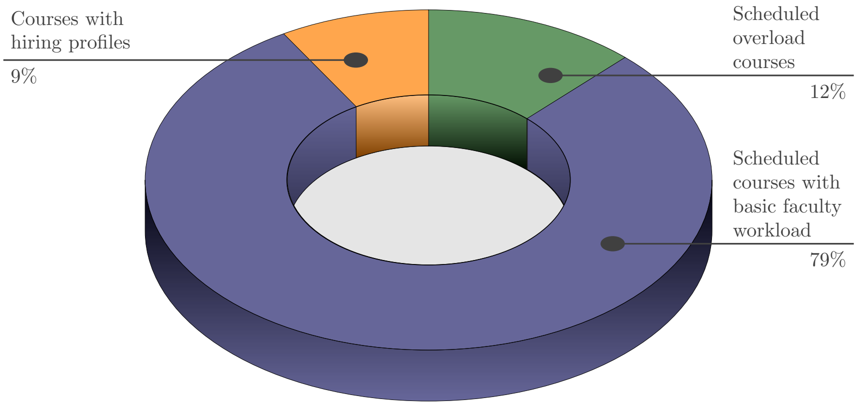

Figure 3. Proportions of courses.

As it was mentioned before, five academic profiles to new hires are defined, based on the composition of the program curricula and the creation of clusters of courses. This allows to identify the exact number of new hires needed. In this case, four professors are needed (one SA-participating, one PA-participating, two SP-supporting) each one belonging to a different academic profile. These new hires are the minimum hires to allocate the seven non-scheduled courses.

Beyond the fact that the optimal solution is obtained, it is possible to show the fulfillment of the constraints by observing the information in Figures 1 and 2. The timetabling states that 75 sections were scheduled and assigned a professor and seven sections were not scheduled but have an assigned hiring profile, giving a total of 82 sections (the grand total of sections). Here, constraint (4) is accomplished. Additionally, can be seen how each section for each course is assigned just once (constraint (5)). Constraints (7)–(10) are about the maximum numbers of courses, the course overload and the maximum overload allowed for each professor, for this, the figures (Figures 1 and 2) exhibit how this load is accomplished according to the information presented in Table 1.

Also in Figures 1 and 2, it is seen how the courses of same semester (same color) are assigned in different time (constraint (11)), the courses from first semester to forth semester are scheduled from 7 hrs. to 14 hrs. and the courses from fifth semester to eighth semester are scheduled to 13 hrs. to 20 hrs. or 7 hrs., however, there are some exceptions due to high demand (constraint (12)). As well as, it is possible to observe how the schedule of professors is at different times (constraint (13)) and the courses assigned to them are according to their credentials (constraint (14)). In addition, the timetable includes the consideration that some professors need to have a free afternoon (restriction (15)–(19)) in order to be able to teach graduate courses.

The total courses assigned to participating faculty already hired by the university (55 sections), plus the courses not scheduled but assigned to a profile (seven sections) must be greater than or equal to 60% of the total Sections (50 sections). Here constraint (21) is accomplished. For constraints related to accomplish of percentages per category (23)–(25), the results can be reviewed in Section 5.5.

To access the complete output, please refer to the data availability statement in the section.

5.2. Minimizing Courses without Schedule and Zero Teaching Overload

In the Figures 4 and 5 the timetables for the two schemes of days are presented for the application of second strategy. As is shown, when the problem presented before is solved minimizing the courses without schedule and zero teaching overload, the model can assign 69 sections with the number of available professors. The 13 remaining courses are: two sections of course ID3, four sections of course ID4, one section of course ID6, one section of course ID15, one section of the course ID20, two sections of course ID 21, and two section of the course ID24. In contrast with the first strategy, this one requires new hires to assign seven different courses, and, if the courses are not from common knowledge areas or require the same academic profile, then it will result in more hires. For this strategy, these courses are linked to academic profiles resulting in a number of six teachers needed. The distribution of this new hires, are: one PA-participating (full-time) profile and five SP-supporting (part-time) professors. The number of five SP-supporting professors needed is calculated based on the number of different courses without schedule and on the maximum load to be assigned to a full-time professor or part-time professor.

	Days			
Time	Monday, Wednesday, Friday			
07:00-08:00	C25S1P16	C11S1P15	C15S3P26	C3S4P10
08:00-09:00	C8S6P4			
09:00-10:00	C9S5P18	C12S1P19	C6S1P21	
10:00-11:00	C16S4P12	C25S6P5		
11:00-12:00	C19S1P27	C9S2P18	C12S2P19	C8S5P4
12:00-13:00	C7S2P17			
13:00-14:00	C16S1P27	C25S3P7	C22S1P13	
14:00-15:00	C9S4P18	C25S2P6	C18S2P2	C26S2P11
	C23S4P23			
15:00-16:00	C9S3P18	C25S4P16	C23S2P1	
16:00-17:00	C17S2P17	C22S2P13		
17:00-18:00	C2S1P20	C27S2P15		
18:00-19:00	C14S1P6	C5S1P9	C26S1P11	C23S1P23
19:00-20:00	C14S2P6	C17S1P17	C28S1P21	

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Figure 4. Timetable of second strategy for courses in day scheme A: Monday, Wednesday and Friday, three classes of 1 h per week.

	Days			
Time	Tuesday and Thursday			
07:00-08:30	C16S5P28	C8S4P23	C18S3P2	C1S2P24
	C22S3P13			
08:30-10:00	C16S2P27	C12S3P19	C8S2P3	
10:00-11:30	C7S1P17	C13S1P9	C8S1P4	
11:30-13:00	C16S3P28	C12S4P19	C8S3P21	
13:00-14:30	C9S6P25	C25S5P7	C11S2P8	C20S2P3
	C1S1P24	C23S3P1		
14:30-16:00	C16S6P28	C9S1P25	C10S1P15	C3S5P14
16:00-17:30	C2S4P21	C27S1P24		
17:30-19:00	C18S1P2	C2S2P8	C3S6P10	
19:00-15:00	C2S3P20	C15S2P26	C3S2P14	

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Figure 5. Timetable of second strategy for courses in day scheme B: Tuesday and Thursday, two classes of 1 h and a half per week.

5.3. Minimizing Courses without Schedule and Teaching Overload

In the Figures 6 and 7 the timetables for the two schemes of days are presented for the application of the third strategy. If the problem is solved considering the minimization of courses without schedule and teaching overload, the model assigns 71 sections with the number of available professors and suggests to hire five professors to teach eleven courses and only two professors will have one extra course as teaching overload. The courses to be assigned to new hires are: three sections of course ID3, three sections of course ID4, one section of course ID6, one section of course ID18, two sections of course ID 21, and one section of the course ID28. With the first strategy, seven sections of four different courses implied four new hires, while in the second strategy, thirteen sections implied five new hires, and with the application of the third strategy, eleven sections of seven different courses resulted in five new hires. This shows that to the extent that unscheduled courses are more and different, this results in a greater need for new hires.

	Days			
Time	Monday, Wednesday, Friday			
07:00-08:00	C11S2P15	C26S2P11	C3S6P10	
08:00-09:00	C9S5P18	C8S5P23		
09:00-10:00	C16S1P27	C8S1P4		
10:00-11:00	C25S5P14			
11:00-12:00	C16S2P27	C7S1P17	C12S3P19	C25S6P7
12:00-13:00	C9S4P25	C25S1P7		
13:00-14:00	C16S6P12	C7S2P17	C12S4P19	C25S3P16
	C2S3P8	C26S1P11	C27S2P24	
14:00-15:00	C13S1P9	C25S2P5	C2S4P2	C22S3P13
15:00-16:00	C16S4P28	C10S1P8	C3S4P6	
16:00-17:00	C17S1P17	C23S2P1		
17:00-18:00	C18S2P20	C20S1P3	C23S3P23	
18:00-19:00	C14S2P6	C5S1P9	C24S2P2	
19:00-20:00	C14S1P6	C17S2P17	C15S1P15	C22S1P13

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Figure 6. Timetable of third strategy for courses in day scheme A: Monday, Wednesday and Friday, three classes of 1 h per week.

	Days			
Time	Tuesday and Thursday			
07:00-08:30	C9S6P25	C12S2P19	C8S2P4	C11S1P15
	C4S4P18	C23S4P1		
08:30-10:00	C19S1P27	C9S2P18	C12S1P19	C8S3P23
10:00-11:30	C16S5P28	C8S4P4		
11:30-13:00	C16S3P28	C9S3P18	C25S4P16	
13:00-14:30	C9S1P18	C6S2P21	C18S1P20	C2S1P2
	C1S1P24	C22S2P13		
14:30-16:00	C8S6P21	C20S2P3	C23S1P23	
16:00-17:30	C2S2P22	C15S3P26	C24S1P10	
17:30-19:00	C1S2P22	C27S1P24		
19:00-15:00	C15S2P26	C3S2P14		

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Figure 7. Timetable of third strategy for courses in day scheme B: Tuesday and Thursday, two classes of 1 h and a half per week.

5.4. Minimizing Hiring Profiles (Professors)

In Figures 8 and 9 the timetables for the two schemes of days are presented for the application of the fourth strategy. When we solve the problem considering the minimization of hiring professors Equation (3), the model can assign 75 sections with the number of available professors and suggests to hire three professors to teach seven courses and eight professors will have teaching overload. The courses to be assigned to new hires are: three sections of the course ID3, three sections of the course ID9, and one section of the course ID24. Compared to the previous strategies, this one consists of assigning sections to new hires from only three different courses. This can result in similar academic profiles.

	Days			
Time	Monday, Wednesday, Friday			
07:00-08:00	C19S1P27	C6S1P21	C14S1P6	C2S3P20
	C4S4P18	C23S2P23		
08:00-09:00	C25S3P14			
09:00-10:00	C8S1P3			
10:00-11:00	C7S2P17	C12S2P19	C8S3P23	
11:00-12:00	C7S1P17	C12S1P19	C25S6P16	
12:00-13:00	C16S5P28	C8S5P4		
13:00-14:00	C8S4P4	C18S2P2	C26S1P11	C22S2P13
14:00-15:00	C13S1P9	C8S2P23	C2S2P24	C1S2P2
	C3S4P10			
15:00-16:00	C6S2P21	C20S2P9	C21S1P6	C27S1P15
16:00-17:00	C5S1P9	C26S2P11	C23S4P1	
17:00-18:00	C20S1P3	C4S2P18	C23S3P23	
18:00-19:00	C18S3P20	C15S2P15	C3S5P10	
19:00-20:00	C2S4P24	C23S1P1		

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Figure 8. Timetable of fourth strategy for courses in day scheme A: Monday, Wednesday and Friday, three classes of 1 h per week.

	Days			
Time	Tuesday and Thursday			
07:00-08:30	C16S4P28	C9S6P25	C12S4P19	C8S6P4
	C17S1P13	C4S3P18	C27S2P24	
08:30-10:00	C16S2P17	C12S3P19	C25S4P5	
10:00-11:30	C16S1P28	C9S3P25	C10S1P15	
11:30-13:00	C16S6P7	C25S5P5		
13:00-14:30	C16S3P27	C25S2P16	C11S2P8	C17S2P17
	C21S2P6	C22S1P13		
14:30-16:00	C9S1P18	C25S1P7	C14S2P6	C1S1P22
	C22S3P13			
16:00-17:30	C18S1P20	C15S1P26	C3S3P10	
17:30-19:00	C4S1P18	C24S1P2		
19:00-15:00	C11S1P14	C2S1P8	C15S3P26	C28S1P22

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Figure 9. Timetableof fourth strategy for courses in day scheme B: Tuesday and Thursday, two classes of 1 h and a half per week.

5.5. General Analysis

In the following, it is explained the behavior of each strategy in relation to the dedication of time of faculty to the mission (AACSB), also the impact of the objective function in the strategies regarding to new hires.

Table 2 presents the percentages of time dedication to the business school mission for each faculty qualification categories based on the AACSB standards. The obtained percentages are calculated for the four strategies established, strategy 1: to minimize the courses without schedule allowing course overload (base case); strategy 2: to minimize the courses without schedule and zero teaching overload; strategy 3: to minimize the courses without schedule and teaching overload; and, strategy 4: to minimize hiring profiles (professors). The percentage of dedication is obtained from the actual faculty and the new hires obtained from the application of the strategies.

Table 2. Percentage dedication of time of faculty to the Mission by strategy.

Strategy	SA	PA	SP	IP	A
Strategy 1	62%	6%	6%	21%	5%
Strategy 2	57%	6%	9%	23%	5%
Strategy 3	61%	2%	9%	23%	5%
Strategy 4	65%	1%	5%	24%	5%

In general, the percentage of time dedication to the mission for SA faculty states over 40% and the largest value (65%) was obtained with the strategy 4. Strategy 2 results in the lowest percentage (57%) for SA faculty. The actual faculty in this case has a greater number of faculty in SA and SP categories, this is why the lowest values in all faculty qualification categories are for the PA, SP and A categories in all the strategies.

Table 3 shows the distribution of new hires that are needed when one of the four proposed strategies is implemented. The first strategy minimizing the courses without schedule allowing course overload needs to hire one professor of SA profile, one professor of PA profile and two professors of SP profile, while the second strategy minimizing courses without schedule and zero teaching overload requires one professor PA and five professors of SP profile. The third strategy minimizing courses without schedule and teaching overload needs five professors of SP profile and strategy four, minimizing hiring profiles (professors) needs one professor of SA profile, one professor of SP profile and one professor of IP profile.

Table 3. Number of new hires needed by strategy.

Strategy	SA	PA	SP	IP	A
Strategy 1	1	1	2	0	0
Strategy 2	0	1	5	0	0
Strategy 3	0	0	5	0	0
Strategy 4	1	0	1	1	0

As it is seen, the first strategy suggests hiring four professors, less professors than strategy two or strategy three, due to the objective function that minimizes the courses without schedule and allows teaching overload, so with this objective, the model will try to assign more courses to current faculty and hire less professors. On the other hand, strategy two, requires six professors; in this second strategy, the objective function tries to minimize the courses without schedule, but here, the teaching overload is not allowed. This is why; this model suggests hiring more professors than any other strategy, because the teaching overload is not allowed, so the model assigns only the workload allowed to all faculty and suggests hiring more professors in order to cover the courses. In the third strategy, the model suggests hiring five professors; here, the model tries to minimize the aggregation of courses without schedule and teaching overload, it is important to notice than in this strategy all new hires are part-time (SP) given the conditions stated in Section 4. Strategy 4, suggests hiring less professors than any other strategy, due to, the model tries to minimize the hiring profiles, so, the timetable is created leaving the courses of the same profiles without schedule in order to hire less professors. The higher number of hire professors in all strategies is presented in the category SP.

6. Conclusions

This paper proposes an integer programming model to create the timetable of an academic department considering basic workload and course overload, as well as the profile and area of knowledge of each professor. The novelty in this paper is the incorporation of necessary requirements to fulfill the standards of AACSB, the most important accrediting association for business schools. It is well known that an accreditation as AACSB demands qualified faculty in each category and it is preponderant for business schools to have tools like the proposed here to support the decision making process.

The model was solved with data from a real case utilizing four different strategies that show the impact of allowing course overload and new hires. In all cases, the requirements of AACSB were met. This model will be useful to help the administration to select the best option that aligns with the objectives of the university. In this particular case, it was identified that the fourth strategy (minimize hires) is one of the best options given that it reduces the cost of new hires. This is why the course overload is a valuable resource that contributes to the last mentioned objective.

It is also common for universities that apply course overload to have a policy that establishes the maximum overload to be assigned to professors according to their hiring (the course overload implies an additional payment to a full-time professor). Therefore, it is important to explore the strategies and policies of an institution that impact the course timetabling and professor assignment.

In order to replicate this model, we suggest to classify the professors into full-time and part-time and according to the qualification categories (SA, PA, SP, IP, A), and participating or supporting (required by AACSB); to collect all the information related to the professors as the number of courses allowed to teach, as well as the courses they can teach according to their expertise. One important and necessary element is to define the time slots where the courses can take place.

The number of courses that can not be scheduled will require new hires, but identifying how many new hires are needed is important to know the knowledge area of the courses to create some categories of hiring profiles. For example, the courses about decision making methods, the courses about strategy and others. We divided the total set of disciplinary courses into disjoint sets to define these new hire profiles. In this sense, the current faculty can provide a first way to define the hire profiles with the courses that they teach as a reference.

Finally, it is important to know the strategy that the university wants to follow in order to use an appropriate objective function or criteria.

As future work, it is contemplated to add the preferences of time slots for faculty and additional necessities (course language, balancing the number of courses scheduled in the same time slot, room assignment, etc.). Further, the budget for new hires could be considered in order to not exceed the academic department budget.

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Abbreviations

The following abbreviations are used in this manuscript:

AACSB	Association to Advance Collegiate Schools of Business
UCTP	University Course Timetabling Problem
AQ	Academic Qualified
P	Participating Faculty
S	Supporting Faculty
SA	Scholarly Academic Faculty
PA	Practice Academic Faculty
SP	Scholarly Practitioner Faculty
IP	Instructional Practitioner Faculty
A	Additional Faculty

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