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Soccer Training Scheduling Problem

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Abstract. This article aims to present a new problem of planning of resources and activities related to soccer, which is a variant of the Project Scheduling Problem. Soccer projects are intended to meet the requirements and expectations of time, cost and quality of the processes of the Soccer-related activities. In this article, original and unique in the world to date, is presented the mathematical modelling based on the Project Scheduling Problem of soccer in order to make optimal use of the resources of time, money and human resources of enterprises that you take care to engage in Soccer. The CPLEX model was used to find the optimal use of resources of the Soccer Project Scheduling Problem.

Keywords: Project Scheduling Problem; Soccer Scheduling Problem, Artificial Intelligence, Combinatorial Optimization Problem, Complexity.

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1 Introduction

Ruiz-Vanoye et al. [14] proposed the definition of Project Scheduling Problem (PSP) as a generic name assigned to a set of problems where it is necessary to optimize the activities based on resources and time. Similar to PSP for Software Development, generically, a Project model can be presented as a set of activities, a set of human resources' skills and a total time divided by activities' times [15].

We proposed the Soccer Training Scheduling Problem (STSP) as a variant of PSP where the Soccer Training Model can be presented as a set of soccer training activities, a set of players' skills and a set of resources specified on money and a total time divided on time per activity.

The main, original and unique contribution of this article is the presentation of the modelling of the characteristics of the problem of planning of Soccer-related activities, the characterization of the problem instances. In section 2 are related works, tools and methods used, the new mathematical model formulation and characterization of the problem, section 3 presents the experimentation of the problem with the CPLEX software and the last section presents the conclusions. In the present work is aimed at optimizing the resources of the Soccer-related activities based on the proposal of human resources, development time of the activities, characteristics of the activities and scheduling activity.

2 Related Works

There are several works related to problems of planning a project of technological innovation. We are only some of the most popular.

Duran et al. [1] presented the Chile's professional soccer league management based on a game-scheduling system - integer linear programming model. In this league, the managers considered several criteria to manage the league like: operational, economic, and sporting. The proposal generates the tournaments' scheduling optimizing the costs, incomes, and fairer seasons. In this example, we go deeper into describing the requirements of the problem.

The Chilean Asociación Nacional de Fútbol Profesional (ANFP) has requirements established for the 2006 tournaments:

(1) Each team plays with teams once.

(2) Each team plays at home or away.

(3) Each team plays nine or ten rounds at home.

(4) Each team plays two consecutive rounds at home maximum.

(5) Each team plays two consecutive rounds away maximum.

(6) Must be a balance the teams' home and away games between the early and late stages of the tournament.

(7)(8)(9) Balance of rounds between north and south games.

(10) If a Center team plays two consecutive away games, one must be played in the Center.

11) If a team plays at home (away) against Colo Colo, it plays away (at home) against Universidad de Chile.

(12) The three classic matchups between these popular teams must be played between the 10th and 16th rounds; however, parameters may change from tournament to tournament.

(13) Each of these three teams plays exactly one classic matchup at home.

(14) Balance of North and South games of the popular teams.

(15) The three popular teams can't play in the first five rounds in outlying areas.

16) Each team can't play two consecutive games against a strong team.

(17) Games between CBLOA and the popular teams are played between the 6th and 18th rounds.

(18) When one team of a crossed pair is playing at home, the other team plays away, and vice versa.

(19) Regional classic games are held between the 8th and 18th rounds.

(20) The number of games Santiago must be between two or four in each round.

(21) The four Santiago teams with the lowest drawing power not play against each other in the first five rounds.

(22) Each team located in a tourist area plays at home against at least one of the popular teams in one of the first five rounds.

(23) If teams have not their playing fields ready, they'll play the first round away.

(24) Not more than three games between teams of the same group are held in the last round.

(25) Each North (South) team shall play at least once at home against a North (South) team.

In this case, the ANFP selects the final schedule from among a series of options presented by the iterative process based on the objective function.

Duran et al. [1] improved their previous proposal based on integer programming formulation, they used a branch-and-cut strategy to speedup convergence.

x_{ijk} = 1 when team *i* plays against team *j* in round *k*.

y_{ik} = 1 when team *i* plays two times (*k* and *k*+1) at home or away

z_{ik} = 1 when team *i* plays at home in round *k*.

Duran et al. [2] compared the results with the proposal at Duran et al. [1] in Table 1. For each algorithm, the authors report the objective function, the number of nodes and the integrality gap after some elapsed times. B&B-ANFP finds good solutions faster than B&C-ANFP at the beginning, but was not able to find the optimal solution within a 4-hour time limit. The results of B&C-ANFP were able to improve the linear relaxation bound at 2 hours top.

Table 1. Comparison between algorithms B&B-ANFP and B&C-ANFP.

Elapsed time	B&B-ANFP			B&C-ANFP		
	Objective	**nodes**	**Gap (%)**	**Objective**	**nodes**	**Gap (%)**
10 minutes	617	140	3.6	474	120	25.9
30 minutes	622	600	2.9	615	330	3.9
1 hour	631	1120	1.4	633	570	1.1
2 hours	633	2190	1.1	640	1560	0.0
4 hours	639	4860	0.2	-	-	-

Urritia and Ribeiro (2009) proposed an Integer Programming Model to solve a mirrored double round-robin tournament at the first phase (second phase are played in the same order, but with interchanged venues).

The model is presented as a set of teams $T = \{1, 2, ...n\}$. The teams are indexed by $2e - 1$ and $2e$ for $e = \{1, 2, ..., n\}/2$. The feasible home-away patterns are represented as a set of $H = \{1, 2, ..., N\}$ at the first phase. the authors presented a $h(\mathrm{l}, k) = 1$, for each round $k = \{1,2, n\text{-}1\}$ and pattern $\mathrm{l} = \{1,2, ..., N\}$ when the team plays at home in round k. In this case the decision variables are (1-2):

$$x_{ijk} = \begin{cases} 1, if\ team\ i \in T\ plays\ at\ home\ against\ team \\ \qquad 0, otherwise; \end{cases} \tag{1}$$

And

$$y_{el} = \begin{cases} 1, if\ team\ 2e-1\ follows\ pattern\ l \in H\ and\ team\ 2e\ follows\ its \\ \qquad complement\ for\ every\ parie = 1, \ldots, n/2 \\ \qquad 0, otherwise; \end{cases} \tag{2}$$

The set of cities are represented as a set of C={São Paulo=1, Rio de Janeiro=2; Belo Horizonte=3, Porto Alegre=4, and Goiânia=5}, where each team has a city presented as T(c)⊂T where the city c∈C. the authors presented a set of rounds R'⊂{1,2,...,n-1} based on the requirement C.2 at Urritia and Ribeiro (2009), and a set of double weekend rounds D ⊂{1,2, ..., n-1}\R'.

In this case, the tournament 2010 was presented as:

T(1) = {11 12, 19, 20}
T(2) = {7 8, 13, 14}
T(3) = {3,4}
T(4) = {15, 16}
T(5) = {1, 2}
SP = T(1)∪{17, 18}
R = {1, 2, 3, 16, 17, 18, 19}
D = {11, 12, 13, 15}
G12 = {3, 4, 7, 8, 11, 12, 13, 14, 15, 16, 19, 20}

The objective function and the constraints are presented as equations (3-7):

$$max \sum_{k\in D} \sum_{c\in C} \sum_{i\in T(c)} \sum_{\substack{j\in T(c)\\ j\neq i}} (x_{ijk} + x_{jik}) \tag{3}$$

$$\sum_{k=1}^{n-1} (x_{ijk} + x_{jik}) = 1, \forall i, j \in T: i < j \tag{4}$$

$$\sum_{k=1}^{n-1} x_{2e-1,2e,k} = 1. e = 1, \ldots, n/2 \tag{5}$$

$$\sum_{\substack{c\in C\\ c\neq 1}} \sum_{i\in T(c)} \sum_{\substack{j\in T(c)\\ j\neq i}} (x_{ijk} + x_{jik}) + \sum_{i\in SP} \sum_{\substack{j\in SP\\ j\neq i}} (x_{ijk} + x_{jik}) = 0, \forall k \in \bar{R} \tag{6}$$

$$\sum_{i\in T(1)} \sum_{j\in T(2)} (x_{ijk} + x_{jik}) + 4 \,.\, \sum_{i\in T(1)} \sum_{\substack{j\in T(1)\\ j\neq i}} (x_{ijk} + x_{jik}) \leq 4 \tag{7}$$

3 Integer Programming

The Integer Programming formulation is defined by the objective function (1) and their constraints (2-22) and the solution is solved by CPLEX 10.2, based on 3-phase decomposition:

- Phase 1: the creation of feasible home-away patterns.
- Phase 2: assignment of a different home-away pattern to each team.
- Phase 3: optimal scheduling solution.

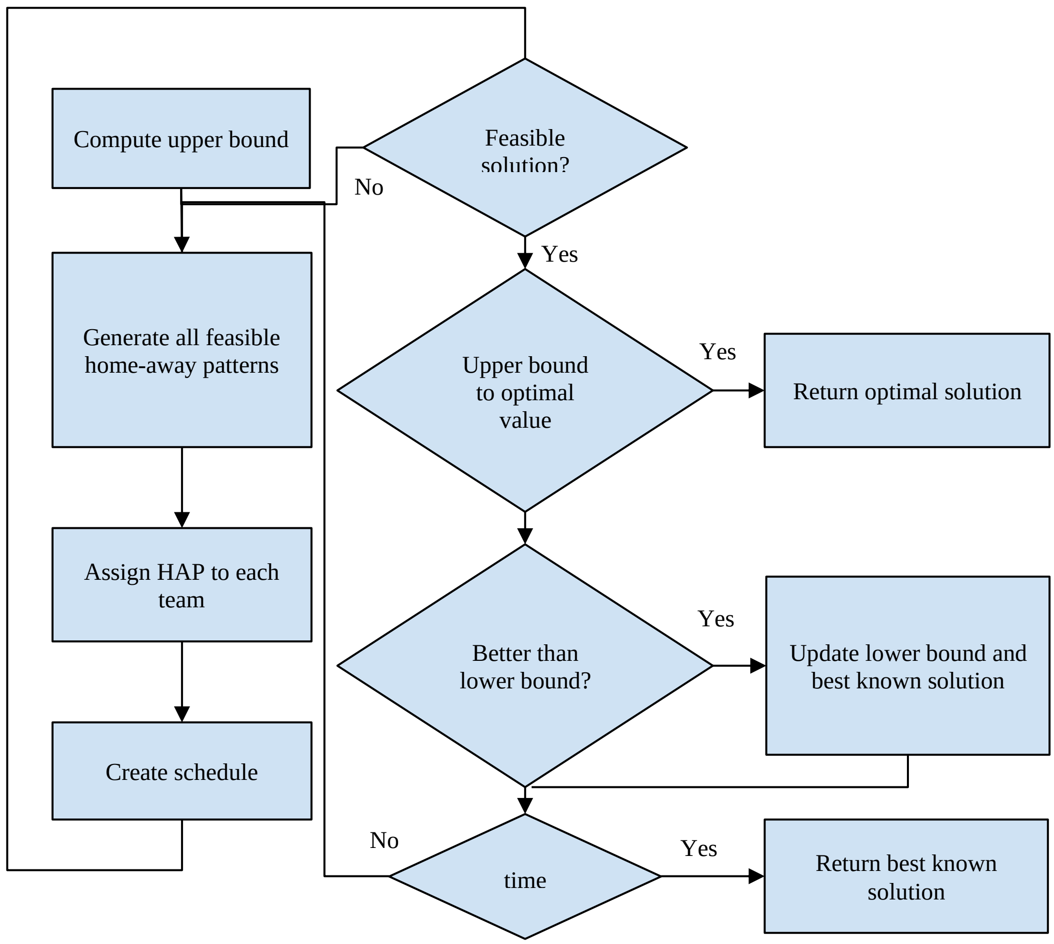

Fig. 1. Solution based on 3-phase decomposition (Urritia and Ribeiro, 2009).

4 Description of the Problem

4.1 Soccer Training Model

In the Soccer Universities, soccer high schools, or other schools related to soccer, the courses scheduling has been performed manually by staff members. The solution by hand usually might fail to satisfy all the constraints. In order to obtain an appropriate solution, the hard and soft (the maximum as possible) constraints have to be satisfied. This problem consists of n training spaces (classrooms, training fields, gam fields, gyms, etc.). There are x instructors to give m activities, where each activity duration can change between 1 and 3 time slots (1 slot = 1 hour). There can be maximum 8 time slots for one day and 40 time slots per week. The hard constraints can be constructed as:

hc1. Each instructor can take only one class at a time.
hc2. Each class can be given by one instructor.
hc3. All classes must start and finish in the same day.

hc4. Two instructors (two classes or two groups) cannot be in the same training space.
hc5. One class cannot be in two training spaces.

The soft constraints taken into account are:
sc1. The number of alternatives that students can attend should be maximized.
sc2. The student conflicts between classes should be minimized.
sc3. Preferences of instructors should be fulfilled.

The Soccer Training Model can be formulated as a constraint satisfaction quadruple (Z, D, C, F) where Z is a set of variables $v = \{x_1, x_2, \dots, x_n\}$, D is a function which maps every variable in Z to a set of objects of defined types. Dx_i is the domain of x_i. And C is a finite set of constraints on a subset of variables in Z. F is the objective function indicated by the quality of the solution.

We use the constraint satisfaction method for an initial timetable satisfying all the hard and soft constraints. We propose a model that consists of a set of resources (instructors, training spaces) and a set of activities (speed activities, teamwork, technical activities, tactical activities, etc.). The time slots (hours) can be assigned a constraint, in a hard constraint the slot is forbidden for any activity, or a soft constraint the slot is not preferred. The classes are presented as activities in the timetabling model. Every activity is defined by its duration (number of time slots), time preferences, and a set of resources. Only one activity can use a resource at one timeslot. Each resource can represent a teacher, a class, a classroom, or another special resource.

The proposal solution of this problem is modelled as a timetable, where each activity has a star timeslot, a set of resources and a finish timeslot. We proposed the technique Project Scheduling Problem defined by Ruiz-Vanoye et al. (2010) as a generic name where interact resources, time, costs and the best solution for project scheduling to solve the Soccer Training Model.

4.2 Soccer Training Scheduling Problem

Fuentes-Penna et al. [3] described the PSP as a directed acyclic graph G represented by a set of nodes G={Nodes, Arcs, Node_0, Node_{n+1}}, where each node represents an interrelated event e through activities arcs, where the $\text{arc}_{(i,j)}$ is the activity between node i and node j. The Graph G has a set of nodes (Nodes), a set of arcs (Arcs), the initial node (Node_0) and the final node (Node_{n+1}). A graph is a mathematical object where the nodes are used to model elements of the problem and the arcs re the relationships between the elements.

Soccer Training Scheduling Problem (SoccerTSP) is a variant of Project Scheduling Problem (PSP) where SoccerTSP can be presented as a directed acyclic graph G where the activities are the classes, trainings, soccer practices, etc.; the nodes are the beginning and ending of the activities, or special triggers; resources can be presented as training spaces and instructors; the cost is presented as the teacher's salary per hour; the students are assigned to groups and each group has several classes in different training spaces; and the best solution is the optimal assignation of the training spaces satisfying the hard and soft constraints.

The general parameters of SoccerTSP are:

A. Resources. The resources are those elements to realize the Soccer activities like: training spaces and instructors.
B. Activities. The activities are defined as a set of operations of the Soccer school.

We propose a new mathematical model of the Soccer Training Scheduling Problem (Soccer-PSP). The mathematical model of Soccer-PSP is formed by the equations 8-12. In this case, we proposed a graph to represent the SoccerTSP, where the instance has the next structure:

$$\max\{f(x): x!\, S\}\, \grave{T}\acute{H} \min\{\acute{H} f(x): x!\, S\} \quad \textbf{(8)}$$

$$graph\ G = (E, L) where\ L \subseteq \{\{u, v\} | u, v \in E\} \quad \textbf{(9)}$$

$$q: E \rightarrow SxT \quad \textbf{(10)}$$

$$\alpha = E \rightarrow \mathrm{P}(SxT) \quad \textbf{(11)}$$

$$Matrix\ M = m_{ij} \quad \textbf{(12)}$$

Where:

f is the cost function and *S* is the set of solutions

E = {e_1, e_2, e_3, …, e_{m1}} set of events

S = {s_1, s_2, s_3, …, s_{m2}} set of training spaces

T = {t_1, t_2, t_3, …, t_{m3}} set of timeslots

P = {p_1, p_2, p_3, …, p_{m4}} set of instructors

A = {a_1, a_2, a_3, …, a_n} set of activities

m1, m2, m3, m4 = {1,2,3,…} integer indexes

q The assignment of the SoccerTSP

α The availability function to determine the available resources for each event

m_{ij} the group g_k taught by instructor p_j in event e_i.

4.2.1 Objective function

The objective function (13) optimize the use of resources to solve the SoccerTSP instances:

- Minimize the project's solution time
- Minimize the cost of the project
- Minimize the resources (instructors, training spaces, timeslots) for each project

$$\min z = \sum_{s_1} \sum_{s_2} \sum_{s_3} d_{s1} r_{s2} t_{s3} \tag{13}$$

Where:

Z objective function

d_{s1} current SoccerTSP Project

r_{s2} Available resources

t_{s3} total time of the current SoccerTSP Project

D={d_1, d_2, d_3, …, d_{s1}} set of projects

R={r_1, r_2, r_3, …, r_{s2}} set of resources

T={t_1, t_2, t_3, …, t_{s3}} set of timeslots

Fuentes-Penna et al. [4] describe the Project Scheduling Problem in the terms of math equations. We reformulate these equations to describe the SoccerTSP as a single project d_j.

d_j is presented as a set $A = \{1, \ldots, n\}$ of soccer activities which have to be processed. The activities are interrelated by two constraints:

1. The precedence constraints force activity not to be started before all its immediate predecessor activities (a1, a2,…, an-1).
2. Second, performing the activities requires resources with limited capacities.

The activities can be classified as:

- Theoretical
- Practical
- Theoretical – Practical

Each activity *c* (class) requires resources represented by r_c. The objective of the SoccerTSP is to find precedence and resource feasible completion times for all activities to minimize the make span of the project. Each activity duration time is a stochastic variable denoted $\xi = \{\xi_{ij}\ (i, j) \in C\}$, $(c_{n1)k}$ denote the duration of activity j and r_j denote the resources of activity c_{n1}. A schedule is given by a vector of duration times TS=(k_1, k_2,…, k_n) and a vector of resources (r_1, r_2,…, r_n). The equation (9) presents the set of activities processed at time t.

$$C(t) = \{k \in K1 | TS_k - p_j\} \quad \textbf{(14)}$$

$$Min\ TS_n \quad \textbf{(15)}$$

$$Min\ R_n) \quad \textbf{(16)}$$

$$TS_c \leq T_j - p_j \quad \textbf{(17)}$$

$$r_c \leq r_j - p_j \quad \textbf{(18)}$$

$$\sum_{j \in C(t)} r_j \leq P_j - p_j \quad \textbf{(19)}$$

$$P_j \geq 0 \quad \textbf{(20)}$$

$j = 1,2, \dots, n; c \in P_j$

The equations (15) (16) denote the objective function to minimize the finish time of the project and minimize the make span using the optimal resources. Constraints of finish time (17) and the constraints of the resources (18) enforce the precedence constraints between activities and these constraints (19) have a limit for each time instance t. The equation (20) defines the decision variables.

4.2.2 Model description

The basis of SoccerTSP is the set of students who are registered in the soccer school (34). Each student belongs to a group g (28) defined by the academic coordinator. In the current school period, each student e has a set of soccer activities C (32) that must be taken in a group g (27). These soccer activities can be classified as theoretical, practical and theoretical-practical (24). Each football activity c (25) has a maximum number of 7 hours per week (timeslots). Each soccer activity has a set of resources R_c required to teach the subject (26). Each football activity has an instructor's profile (23) to be assigned based on the set of skills (21). Each instructor i has an hourly wage (22) based on his/her skills, antiquity, experience, etc. To provide football activities different training spaces s have been assigned (29) that must comply with the profile of the subject. Each training space has a defined capacity (30) and a schedule availability (31).

The present proposal is aimed to optimize the allocation of resources, training spaces and subjects, so based on this proposal we establish a teacher-group-subject-timeslot relationship (33) to reduce the number of variables.

$$i_k: SK_i = \{sk_1, sk_2, \dots, sk_n\} \quad \textbf{(21)}$$

$$i_k: Salary_i \quad \textbf{(22)}$$

$$i_k: T_i = \{t_1, t_2, \dots, t_n\} \quad \textbf{(23)}$$

$$c_k: profile_C = \begin{cases} theoretical \\ practical \\ theoretical - practical \end{cases} \quad \textbf{(24)}$$

$$c_k: T_c = \{t_1, t_2, \dots, t_n\} where\ n \leq 7 \quad \textbf{(25)}$$

$$c_k: R_c = \{r_1, r_2, \dots, r_n\} \quad \textbf{(26)}$$

$$g_k: C_g = \{c_1, c_2, \dots, c_n\} \quad \textbf{(27)}$$

$$g_k: E_g = \{e_1, e_2, \dots, e_n\} \quad \textbf{(28)}$$

$$S_k: profile_S = \begin{cases} theoretical \\ practical \\ theoretical - practical \end{cases} \quad \textbf{(29)}$$

$$Cap_S = \sum_{k=1}^{n} e_x \quad \textbf{(30)}$$

$$s_k: T_s = \{t_1, t_2, \dots, t_n\} \quad \textbf{(31)}$$

$$E_k: c_s = \{c_1, c_2, \dots, c_n\}\ where\ n \leq 6 \quad \textbf{(32)}$$

$$Rel_x(I_{x1}, C_{x2}, G_{x3}, TS_k) \quad \textbf{(33)}$$

$$E = \{e_1, e_2, \dots, e_n\} \ where\ n \leq 20 \quad \textbf{(34)}$$

Where

SK={sk_1, sk_2,…, sk_n} set of skills

E={e_1, e_2,…, e_n} set of students

I={i_1, i_2,…, i_n} set of Instructors

S={s_1, s_2,…, s_n} set of Training spaces

G={g_1, g_2,…, g_n} set of Students Groups

C={c_1, c_2,…, c_n} set of Soccer Activities

T={t_1, t_2, t_3, …, t_{m3}} set of timeslots

k={1,2, …, n}

Cap_s Training Space's capacity

R_c={r_1, r_2,…, r_n} set of resources

5. Experimentation and Results

This section shows the experimentation using software which is one of the most used software CPLEX to solve the cases of the Soccer-PSP. The results were obtained using the CPLEX software to find the optimal cost of PSP-TI on an IBM Proliant server with 32 cores and 4 GB of RAM.

We present the parameters or characterization of the Soccer Project Scheduling Problem of a Soccer University (Table 2, table 3, table 4, table 5 and table 6).

Table 2. The instructors' assignation.

Instructors	sk1	sk2	sk3	sk4	sk5
i1	7	9	8	5	3
i2	4	7	8	1	2
i3	5	4	9	3	8
i4	9	7	3	2	1
i5	9	8	9	4	6
i6	4	7	2	6	9
i7	2	3	4	6	9
i8	1	7	9	3	4
i9	2	3	5	7	8
i10	1	7	4	9	9
i11	6	9	1	7	3
i12	7	6	3	8	9
i13	6	6	6	6	6
i14	9	9	9	9	9
i15	1	3	4	5	7

Instructors	Salary
i1	$ 192.00
i2	$ 132.00
i3	$ 174.00
i4	$ 132.00
i5	$ 216.00
i6	$ 168.00
i7	$ 144.00
i8	$ 144.00
i9	$ 150.00
i10	$ 180.00
i11	$ 156.00
i12	$ 198.00
i13	$ 180.00
i14	$ 270.00
i15	$ 120.00

i16	2	6	7	2	9
i17	2	3	4	5	7
i18	2	3	3	3	3
i19	8	8	8	8	6
i20	9	9	1	1	1

i16	$ 156.00
i17	$ 126.00
i18	$ 84.00
i19	$ 228.00
i20	$ 126.00

Table 3. Instructors' availability.

Instructor Xi						
	M	**Tu**	**W**	**Th**	**F**	**S**
07:00						
08:00						
09:00						
10:00						
11:00						
12:00						
13:00						
14:00						
15:00						
16:00						
17:00						
18:00						
18:00						

Table 4. Students.

Students E ={e1,e2,e3,e4,…,en}

Groups	Students
g1	e1,e7,e10,e24,e32,e50
g2	e2,e3,e4,e5,e6,e11,e12
g3	e14,e21,e25,e26,e49,e52
g4	e31,e37,e8,e49,e9

Students	Soccer activities
e1	c1,c2,c3,c4,c5
e2	c2,c6,c8,c9,c10
e3	c2,c6,c8,c9,c10
e4	c2,c6,c8,c9,c10
e5	c2,c6,c8,c9,c10
e6	c2,c6,c8,c9,c10
e7	c1,c2,c3,c4,c5
e8	c9,c8,c7,c6,c5
e9	c9,c8,c7,c6,c5
…	

Table 5. Soccer activities.

Soccer Activities Cx={c1,c2,c3,c4,c5,c6,c7,c8,c9}

Cx	Timeslots	Acitivy's Profile
c1	4	Theoretical
c2	5	Practical
c3	6	Theoretical
c4	7	Practical
c5	5	Theoretical-Practical
c6	4	Theoretical-Practical
c7	6	Theoretical-Practical
c8	4	Theoretical
c9	5	Practical

Groups	Soccer activities
g1	c1,c2,c3,c4,c5
g2	c2,c6,c8,c9,c10
g3	c3,c5,c6,c7,c8
g4	c9,c8,c7,c6,c5

Table 6. Training spaces.

Training spaces S={s1,s2,s3,s4,s5,s6,s7,s8}

Sx	Profile	Capacity
s1	Theoretical	25
s2	Theoretical	30
s3	Theoretical	35
s4	Practical	25
s5	Practical	30
s6	Practical	40
s7	Practical	40
s8	Practical	20

	Training space S1					
schedule	M	Tu	W	Th	F	S
07:00						
08:00						
09:00						
10:00						
11:00						
12:00						
13:00						
14:00						
15:00						
16:00						
17:00						
18:00						
19:00						

The figures 2, 3, 4 and 5 present the information about training spaces, instructors, timeslots and skills, respectively.

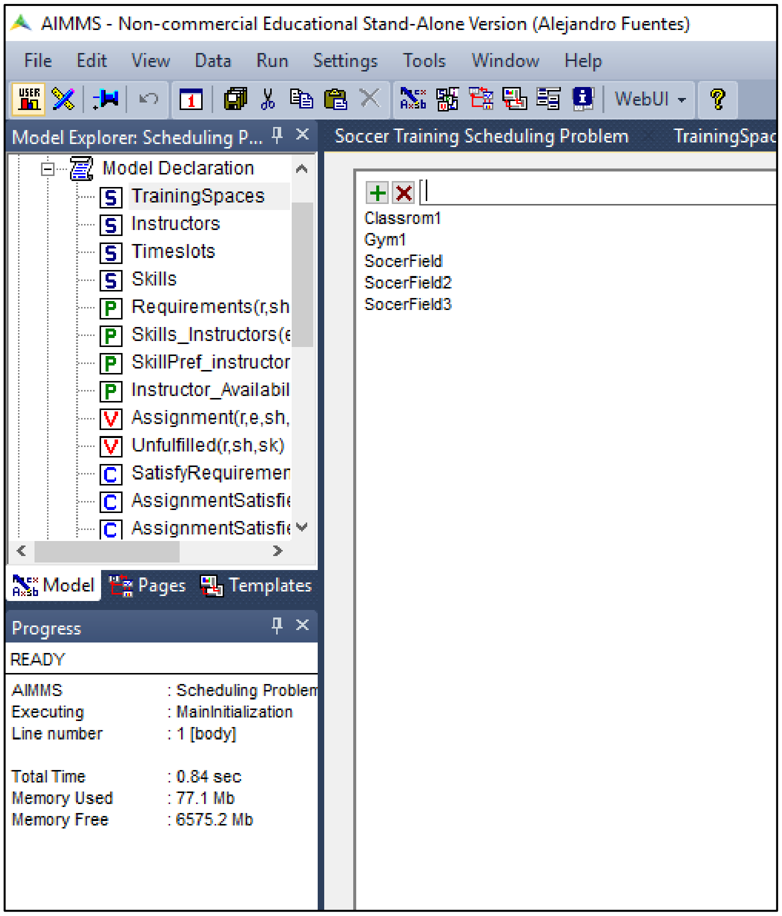

Figure 2. Training spaces.

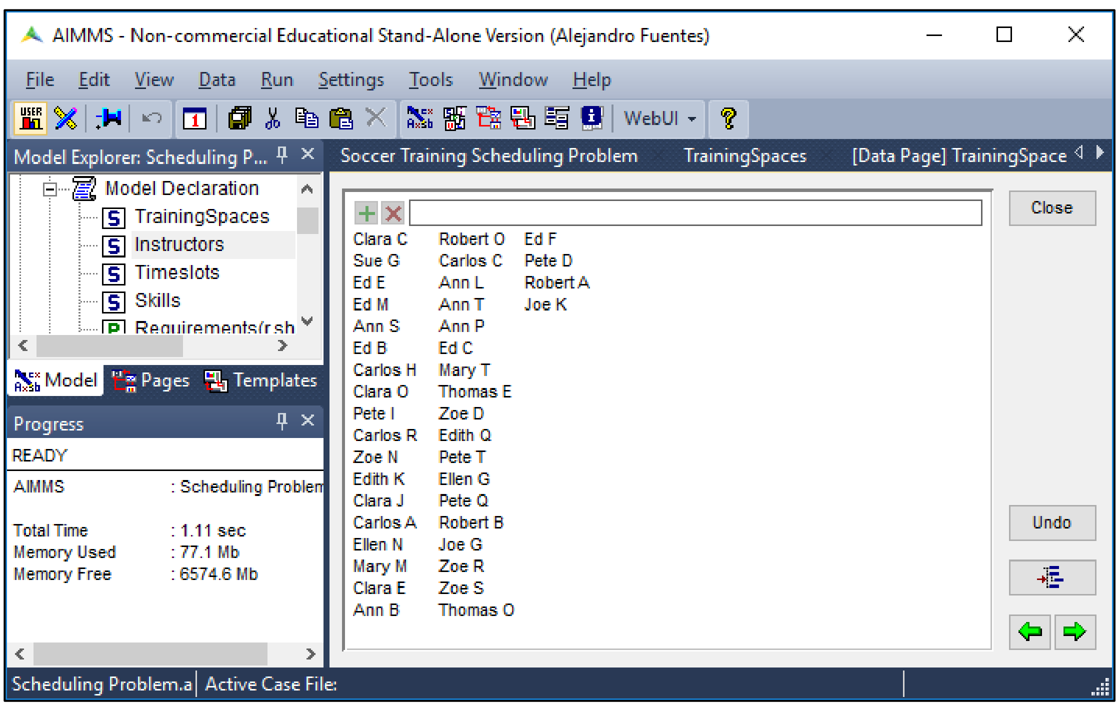

Figure 3. Instructors.

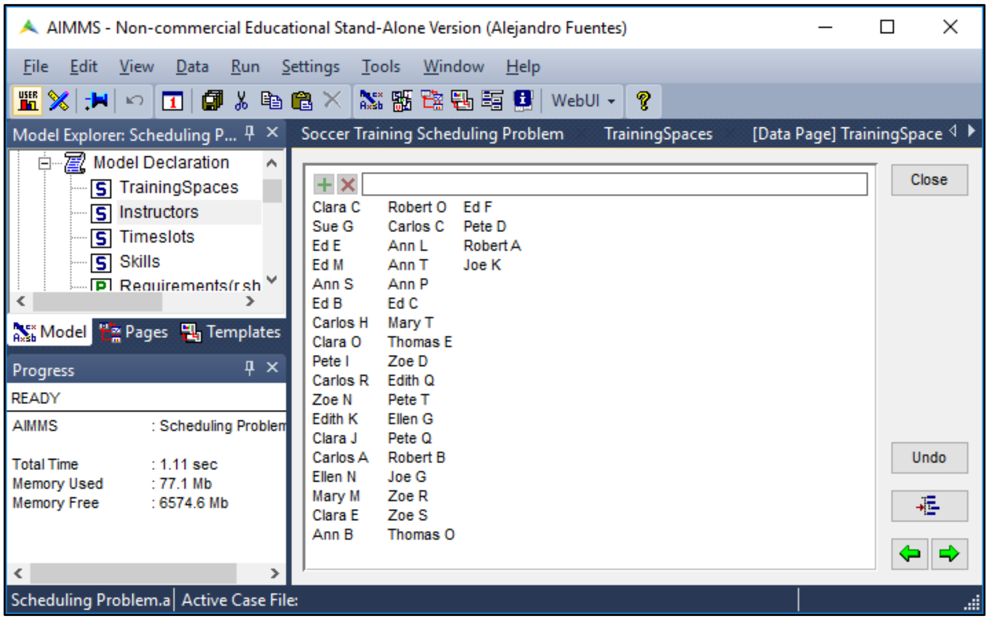

Figure 4. Timeslots.

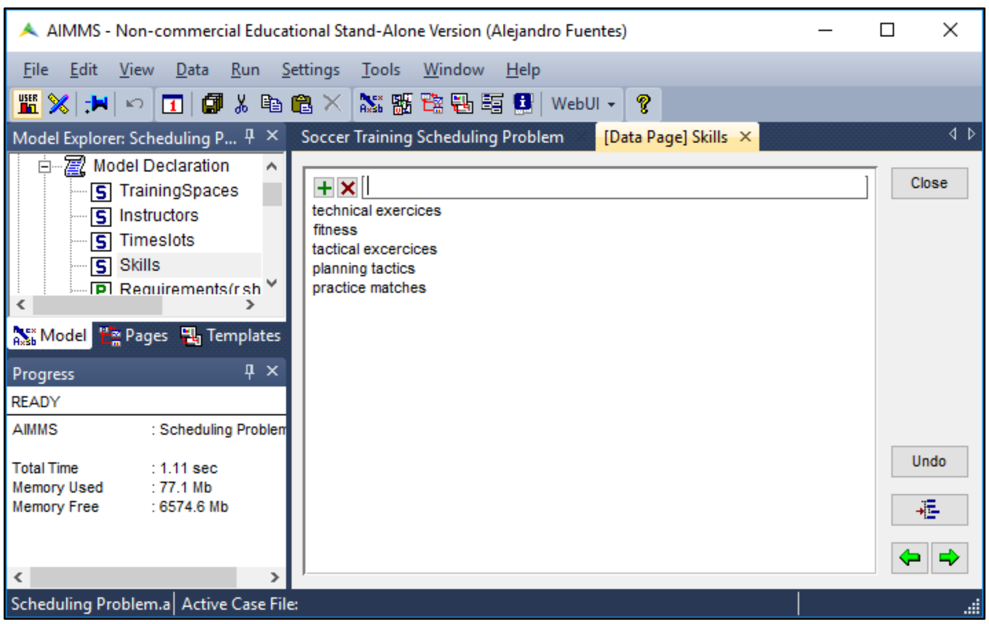

Figure 5. Skills.

The figure 6 presents the needed number of skilled employees in the training activities.

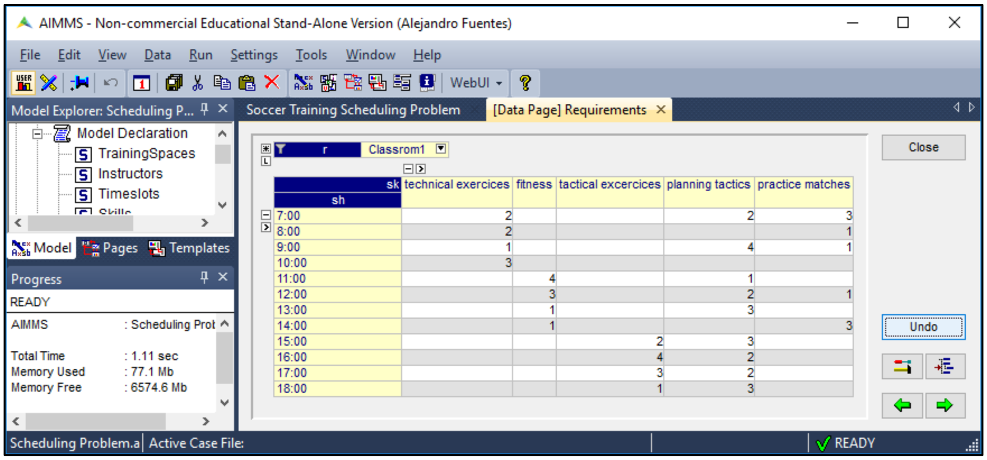

Figure 6. Requirements.

The figure 7 presents the instructors' skills.

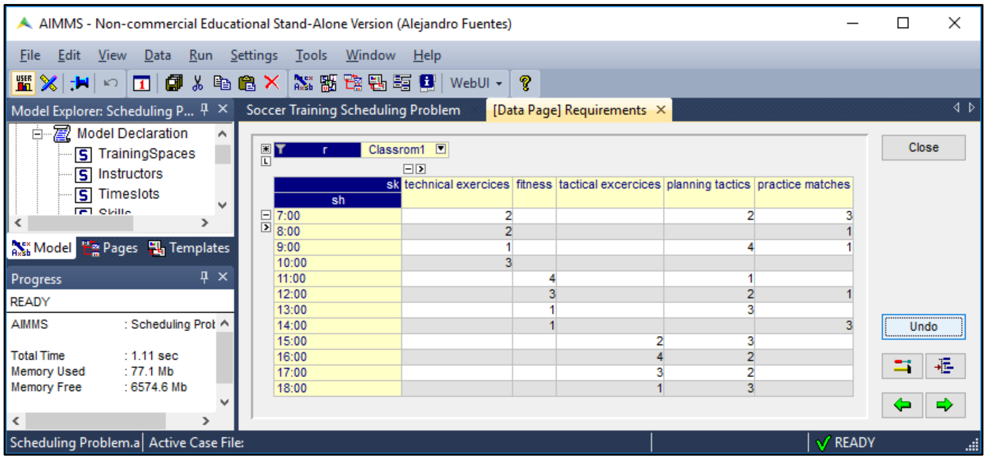

Figure 7. Skills' instructors.

The figure 8 presents Job preferences of the instructors (lower number means preferred position).

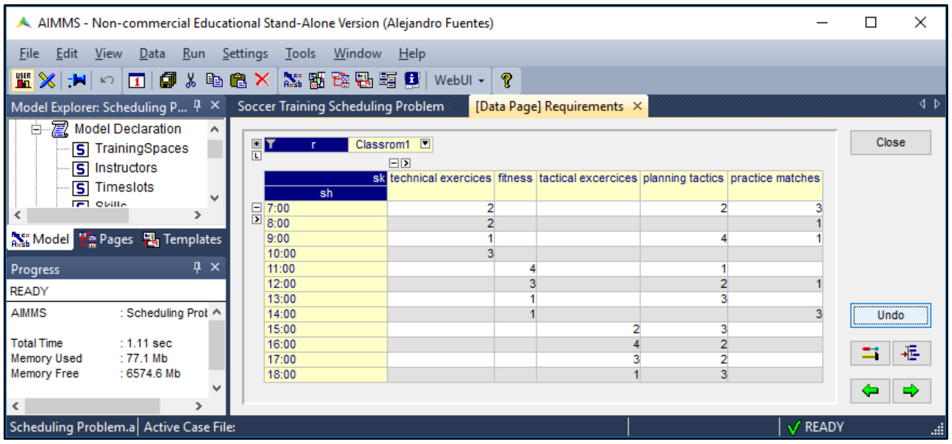

Figure 8. Preferred skills of instructors.

Figure 9 presents Instructors' availability by timeslots.

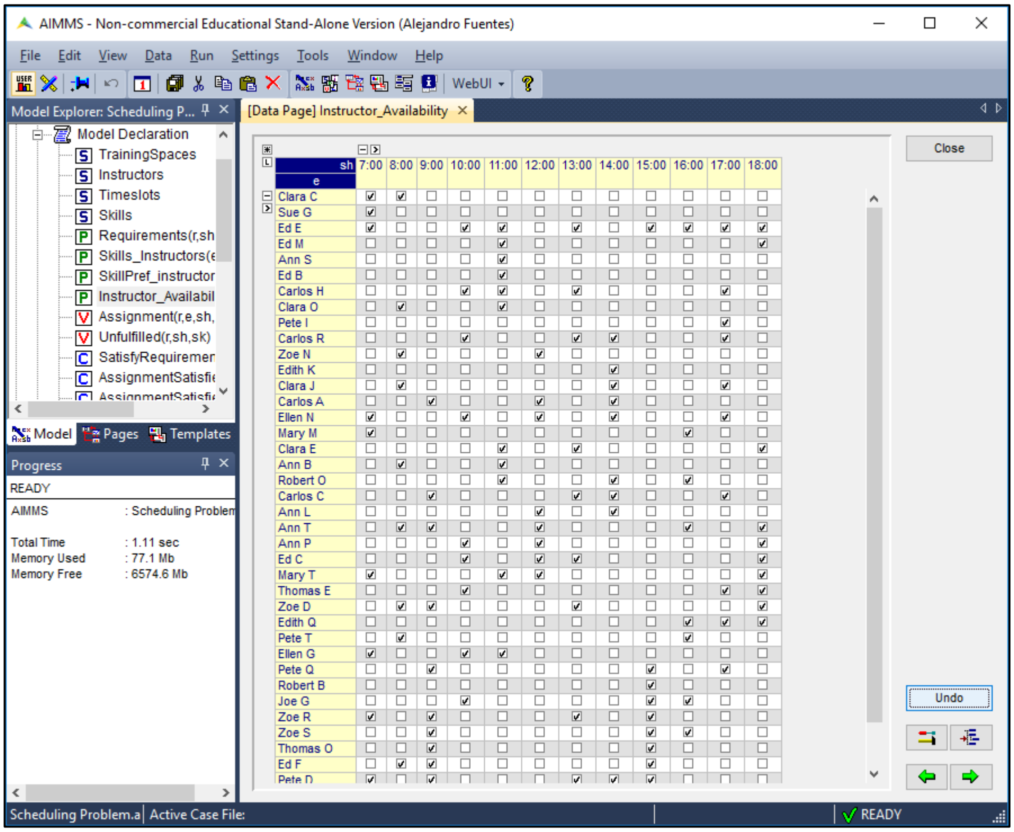

Figure 9. Instructors' availability.

Equation 35 The number of assigned instructors has to be equal to the needed number of instructors minus the unfulfilled positions. Equation 36 If the instructor is available for a timeslot, then he/she can be assigned. Equation 37 If the instructor has the needed skill for a position, he/she can be assigned. Equation 38 an instructor cannot do more than 8 timeslots per day. Equation 39 The total cost caused by unfulfilled positions. Equation 40 the total cost caused by assigning instructors for less preferred positions. And the equation 41 is represented by the sum of equation 39 and 40.

$$\mathrm{sum}\big(\mathrm{e}, \mathrm{Assignment}(\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk})\big) = \mathrm{Requirements}(\mathrm{r}, \mathrm{sh}, \mathrm{sk}) - \mathrm{Unfulfilled}(\mathrm{r}, \mathrm{sh}, \mathrm{sk}) \tag{35}$$

$$\mathrm{sum}((\mathrm{r}, \mathrm{sk}), \mathrm{Assignment}(\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk})) <= \mathrm{Instructor\_Availability}(\mathrm{e}, \mathrm{sh}) \tag{36}$$

$$\mathrm{Assignment}(\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk}) <= \mathrm{SkillS\_Instructors}(\mathrm{e}, \mathrm{sk}) \tag{37}$$

$$\mathrm{sum}((\mathrm{r}, \mathrm{sh}, \mathrm{sk}), \mathrm{Assignment}(\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk})) <= 8 \tag{38}$$

$$\mathrm{sum}((\mathrm{r}, \mathrm{sh}, \mathrm{sk}), \mathrm{Unfulfilled}(\mathrm{r}, \mathrm{sh}, \mathrm{sk}) * \mathrm{UnfulfilledWeightingFactor}) \tag{39}$$

$$\mathrm{sum}((\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk}), \mathrm{Assignment}(\mathrm{r}, \mathrm{e}, \mathrm{sh}, \mathrm{sk}) * \mathrm{SkillPref\_instructors}(\mathrm{e}, \mathrm{sk})) \tag{40}$$

$$\mathrm{UnfulfilledCost} + \mathrm{NotPreferenceCost} \tag{41}$$

The figures 10 and 11 are the execution data for each instance and the characteristics of the hardware's computer, respectively.

AIMMS	: Scheduling Problem.ams	
Math.Program	: MinimizeCost	
# Constraints	: 12823	
# Variables	: 12303	(12000 integer)
# Nonzeros	: 52565	
Model Type	: MIP	
Direction	: minimize	
SOLVER	: CPLEX 12.8	
Phase	: Postsolving	
Iterations	: 0	
Nodes	: 0	(Left: 0)
Best LP Bound	: 6188	(Gap: 0.00%)
Best Solution	: 6188	
Solving Time	: 0.05 sec	(Peak Mem: 0.6 Mb)
Program Status	: Optimal	
Solver Status	: Normal completion	
Total Time	: 0.00 sec	
Memory Used	: 105.8 Mb	
Memory Free	: 5225.3 Mb	

Figure 10. Execution data.

We generated 1 instance set of 25 cases of randomly generated instances. The figures 11, 12, 13 and 14 shows the results of the depository of instances of projects of soccer-related activities by the experimentation of CPLEX solver. We obtain an improved in the total cost requested a number of the workers requested.

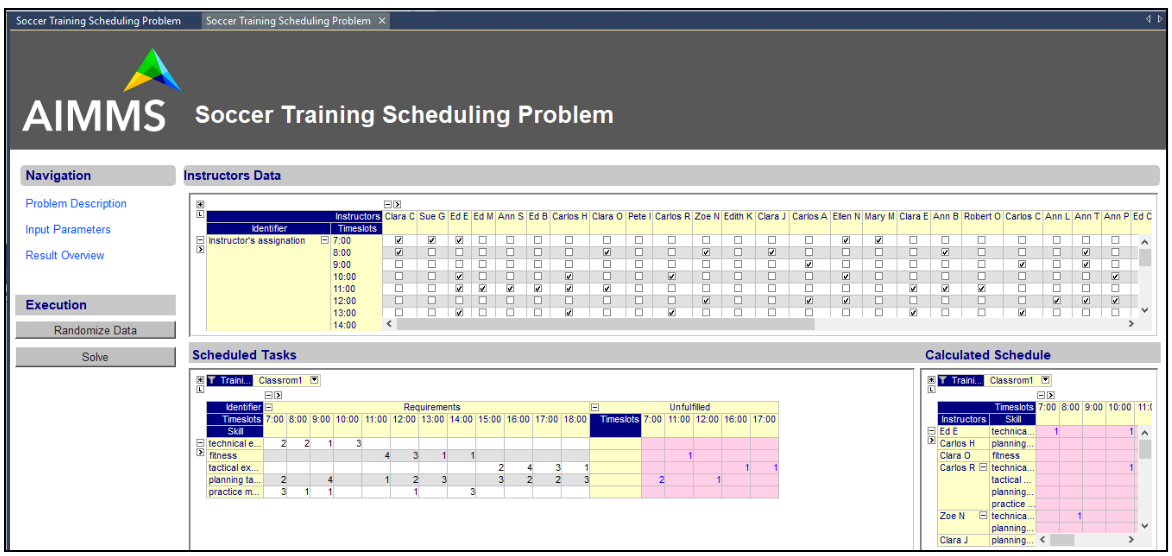

Figure 11. Results of SoccerTSP.

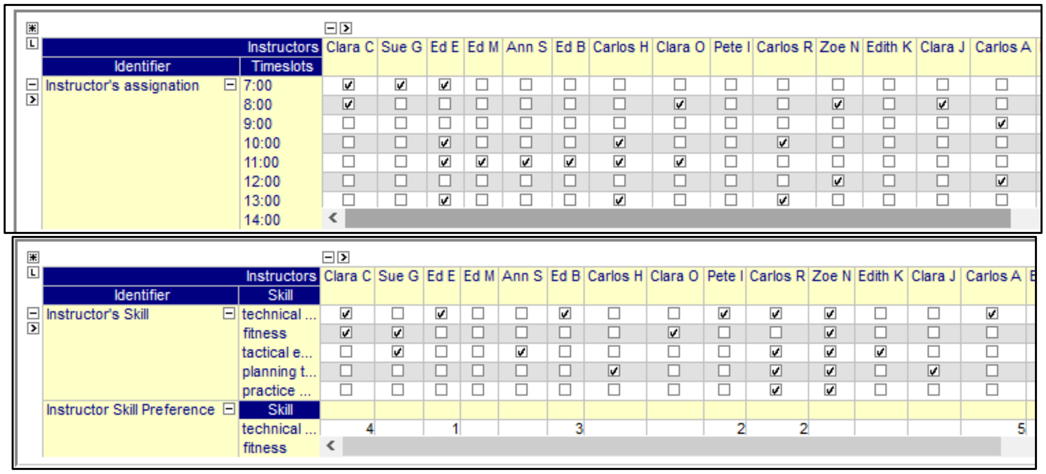

Figure 12. Instructors data.

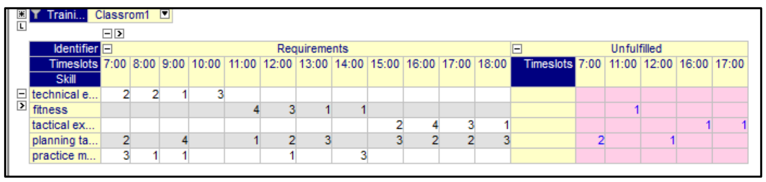

Figure 13. Scheduled tasks.

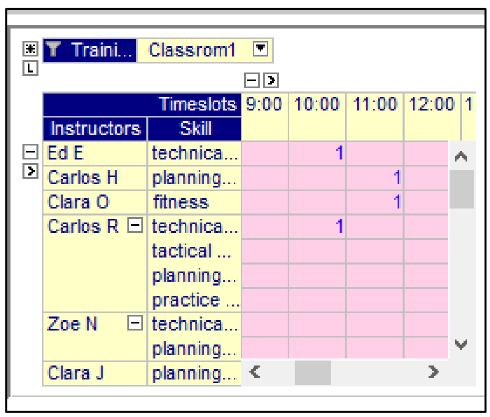

Figure 14. Calculated tasks.

4 Conclusions

With this proposal, the project leader can determine the initial complexity of a set of instructors' assignments for soccer training and it will provide the information related to the possibility of developing each training based on available resources and provide an initial assignment to validate workloads (time per activity, spaces' optimization and skill´s level of each instructor), and a preview projection of the estimated total cost from the weighting in previous projects.

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