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Procedia - Social and Behavioral Sciences 41 (2012) 426 – 433

Procedia
Social and Behavioral Sciences

International Conference on Leadership, Technology and Innovation Management

An application of Soft System Methodology

M. Reza Mehregan[a], Mahnaz Hosseinzadeh[a]*, Aliyeh Kazemi[a]

[a]*Department of Industrial Management, Faculty of Management, University of Tehran, Tehran, Iran*

Abstract

The typical course timetabling problem is assigning Classes of students to appropriate faculty members, suitable classrooms and available timeslots. Hence, it involves a large number of stakeholders including students, teachers and institutional administrators. Different kinds of Hard Operational Research techniques have been employed over the years to address such problems. Due to the computational difficulties of this NP complete problem as well as the size and the complexity of the real world instances, an efficient optimal solution cannot be found easily.

As an alternative strategy, this paper investigates the application of Checkland`s Soft System Methodology (SSM) to the course timetabling problem. Besides giving an ideal course timetable, even to large and complex real problems, application of SSM, generates debate, learning, and understanding; enables key changes; facilitates negotiating the actions to be taken and makes possible the meaningful collaboration among concerned stakeholders. This paper also provides an appropriate course timetable for the management faculty at University of Tehran to show the potential of this application to real problems.

Keywords: Soft System Methodology (SSM); University course timetabling; rich picture; conceptual model.

1. Introduction

It is more than 40 years that Different kinds of timetabling problem have attracted the attention of the operational research communities. One of the typical real world timetabling problems is educational timetabling. The three common categories of educational timetabling are called as examination timetabling [1], course timetabling [2] and class/teacher timetabling [3]. The explanation and distinction of these categories can be found in [4].

The typical course timetabling problem consists of scheduling a set of meetings, between lecturers, and students over a set of time periods, which requires some resources and has to satisfy some additional constraints. It is strongly dependent upon the number of students, teachers, classrooms and periods or sessions. An optimal schedule would be one where no teacher, student or classroom is used more than once at any given period [2]. In University course timetabling, which is the subject of the current

* Corresponding author

E-mail address: mhosseinzadeh@ut.ac.ir.

doi:10.1016/j.sbspro.2012.04.051

research, the assignment of courses to faculty members and then the assignment of these courses to time periods is an important administrative task that must be performed each semester or term. Preparing such timetables can be a tedious and time-consuming task, which entails the activity of a considerable group of people in the registration office for several days.

It seems that the most widely studied class of timetabling problem is the educational timetabling. A wide variety of papers describing a broad spectrum of educational timetabling methodologies has appeared in the literature. An overview of its literature can be found in [5]. Some of the early techniques have being used for educational timetabling are mathematical [6, 7, 8] and binary (integer) programming [2, 9, 10]. Constraint based techniques [11, 12, 13] , Hungarian method [14] and Graph theory based methods [15, 16] have been employed over the years to address such problems. The timetabling problem is known to be NP-complete in their general form [17] regarding its computational complexity, meaning that the difficulty to find an optimization solution rises exponentially to its size. So, apart from the above mentioned techniques, several new and most efficient techniques such as Genetic algorithm [18, 19, 20], Tabu search [21, 22],Simulated annealing [23, 24], Neural networks [4, 25, 26] and Evolutionary methods[27, 28] have also being used for the educational timetabling problems. Recently, combined approach of optimization and heuristic [29], Hyper-heuristic methods [30], Neural network-based heuristics [3], computer network based systems [31] and Decision Support Systems (DSS) [32, 33] are proposed, too. Furthermore, the course timetabling is a problem of increased complexity and of immense size, which is continuously becoming even more large and complex as the universities grow and the teaching programs become more complicated. So, tackling real world situations may entail new strategies to overcome the difficulties of structure complexity or large dimension often present in real instances. The Soft Operational Research (Soft OR) can be regarded as such strategy. In fact, Soft OR methods are those that, in very general terms, structure a problem, as opposed to Hard OR that seeks to solve it. The word "Hard" here refers to the use of mathematical and quantitative techniques whereas softer research employs predominantly qualitative techniques. Soft OR uses qualitative, rational, interpretative and structured techniques to interpret, define, and explore various perspectives of an organization and the problems under scrutiny. They generate debate, learning, and understanding, and use this understanding to progress through complex problems. Soft OR has sought to readdress this fact that people are an integral part of organizations and that these people each bring to the organization their own worldviews, interests and motivations and hence understands the difficulties involved in the predictability of human behavior. Furthermore, soft OR methods seek to help key stakeholders understand the problems they face; the views held by other stakeholders; negotiate the action to take; and agree to a consensus on a course, or courses, of action to be taken [34]. It seems that Soft OR and the related methodologies, has remained unfamiliar to timetabling researchers. So, this paper applies Soft system methodology (SSM) as a useful means for structuring Course Timetabling problems and shows its performance for course timetabling in management faculty, University of Tehran, Iran.

2. Soft System Methodology

Soft Systems methodology was first developed in 1970s by Peter Checkland and his colleagues at Lancaster University, UK. But the methodology, which is pretty much how we know it today, was published in 1981. SSM is an action research method and uses models to structure a debate in which different conflicting objectives, needs, purposes, interests and values can be teased out and discussed [35]. SSM assumes that any complex set of behaviors has unique emergent properties better seen as characteristic of the system as a whole rather than any particular aspect of it. In this way, SSM is a systemic (rather than systematic) methodology: its focus is the whole, rather than the parts [36]. As a systems-based methodology for tackling real-world problems, SSM enables the analyst and the participant to understand different perspectives on the situation and the problem is solved through learning rather than through replacement of the current situation with an espoused improved ideal. Applications of SSM are numerous in the literature [36, 37, 38, 39,40, 41].

The traditional SSM model is broken down into seven distinct stages [42]. The model consists of two types of activities: real-world activities (Stages 1, 2, 5, 6 and 7) and systems thinking activities (Stages 3 and 4). It should be noted that not all of these stages need to be followed.

3. 3. Applying SSM to university course timetabling: management faculty, University of Tehran

3.1. Steps 1 and 2

Finding out the problem situation and expressing it through a rich picture is the first stage in soft system methodology. As with any type of diagram, more knowledge can be communicated visually [43]. As defined earlier, the university course timetabling problem is about assigning Classes of students to appropriate faculty members, suitable classrooms and available timeslots. Different perspectives (students, faculty members, lecturers, etc) should be explored and collaborated in order to deliver an ideal university course timetable. Delivering such timetable helps to satisfy the concerned people which in turn affect the quality of educational activities. Different research methods or quantitative and qualitative analysis can be performed in order to express the problem situation and to elicit results that would enable the production of the Rich Picture and the progression to third step of SSM.

In this case, the academic year is divided into two independent terms, each containing 16-17 weeks and each week is of the 25 timeslots, i.e. 5 days per week and 5 sessions per day. There are 5 departments in the management faculty. The courses offered by departments are comprised of lectures and recitations. But the university course structures considered for the timetabling are just lectures. The timeslots assigned for recitations are settled by the agreement of the students and the lecturer (or his assistant) along the term, in case of necessity. Most (nearly 70%) of the lectures subjects are common among the existing departments. Besides, some particular courses, e.g. English, are presented by three other faculties and hence the timetable of the management faculty should be set in coordination with these distinct faculties. Analyzing the case situation, some interviews were conducted in order to collect qualitative data, primarily. 10 interviewees who were administratively responsible for scheduling and course timetabling in the faculty of management at University of Tehran were asked about the current procedure of educational timetabling, the challenges and the people concerned. In addition, two different open questionnaires were designed and filled by students and faculty members in order to explore the situation from their perspectives. The results included in the rich picture as shown in Fig.2 to reflect the current viewpoints, problems and issues in the university course timetabling.

3.2. Step 3

The third stage is formulating root definitions. A root definition is a sentence that describes the ideal system: its purpose, who will be in it? Who is taking part in it? Who could be affected by it and who could affect it? The root definitions and conceptual models can be formulated by considering the elements of the mnemonic CATWOE [36]. CATWOE elements are Customers, Actors, Transformation process, Weltanschauung, Owner, Environmental factors. The outcome of the CATWOEs based on different perspectives of stakeholders for our case is shown in table 1 and led to the following accommodated root definition:

A system determined and controlled by the faculty educational affairs in cooperation with departments, lecturers and students, preparing fixed university timetable for 7-8 terms of the faculty students in such a way that satisfies concerned people and increases the educational quality.

Moreover, similar root definitions can be proposed for other stakeholders.

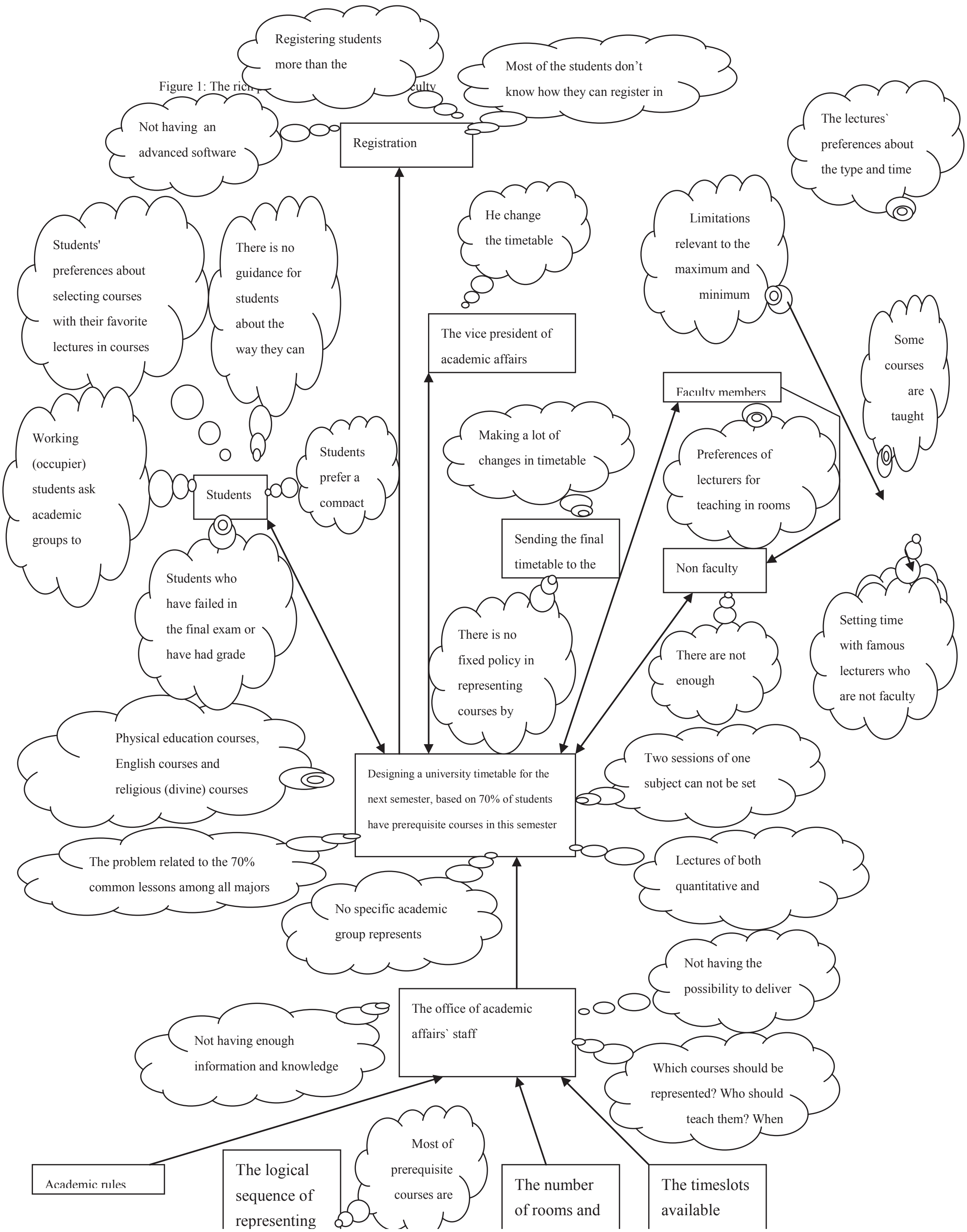

Figure 1: The rich ... culty

Table 1: CATWOE elements for the University course timetabling

CATWOE	The office of educational affairs	lecturers	students
C	Students,lecturers	Students,lecturers	Students,lecturers
A	The office of educational affairs,university administration (by its educational rules)	The office of educational affairs,university administration (by its educational rules)	The office of educational affairs,university administration (by its educational rules)
T	Preparing the draft course timetable in each term considering all the related considerations, receiving the approved one from the departments and performing the registration based on it	The office of educational affairs is informed about the lecturers' preferences on the subject and the time of lectures. The prepared draft timetable will be sent to departments for confirmation.	Students receive the timetable from the office of educational affairs and choose some courses to register
W	The most suitable timetable which satisfies all concerned people and improves the quality of education.	The most compact timetable considering the prefrences on lecturers in order to improve the quality of teaching	The most compact timetable, minimizing the overlapping courses, enabling students to choose their favorite lectures in order to improve the quality of learning.
O	university administration ,the vice president of educational affairs,departments	The office of educational affairs,the vice president of educational affairs,university administration	Educational affairs staff,the vice president of educational affairs, faculty departmnts
E	Constraints related to office of educational affairs	Constraints related to lecturers	Constraint related to students

3.3. Stage 4

Building the conceptual model is the fourth step. The conceptual model [44] is formed to identify the main purposeful activities through a set of logical actions implied by the root definition. Fig. 2 shows a conceptual model based on the mentioned Course timetabling root definition.

3.4. Stage 5

In this stage, models are compared with the real world. In our case, comparing the model with the real world situation resulted in some discussions among the concerned people and included the following questions: Does this happen in the real situation? How does it happen in the real world situation? Based on what criteria is it judged? Is it a concern in the real world situation? In this way, the discussions resulted in the consensus among the concerned people about the proposed model as well as the changes that can be implemented to improve the situation.

3.5. Stage6

This stage involves identifying systematically desirable and culturally feasible changes to the real world system. The feasibility is concerned with the matter of whether or not the potential change we would make is worth pursuing. The Cultural feasibility is considered primarily significant in SSM, and culture is not assumed to be static. Based on the comparisons made in the former stages, the following changes can be considered in our case:

1- Designing a fixed university timetable for 7 and 8 semesters of each student class. 2- Having a primary coordination about the fixed timetable among academic groups. 3- Doing pre-registration for each term. 4- Filling in opinion poll forms by students to make some impartial changes in the fixed timetable for next terms according student's desires. 5- Fixing the culture of being full time at university for lectures and students. 6- Having a fixed approach in assigning common courses to a specific academic group. 7- Improving the software system used for course selection. 8- Making some arrangement to register students with higher score sooner than others. This approach let them select courses with their favorite lecturers before being full.

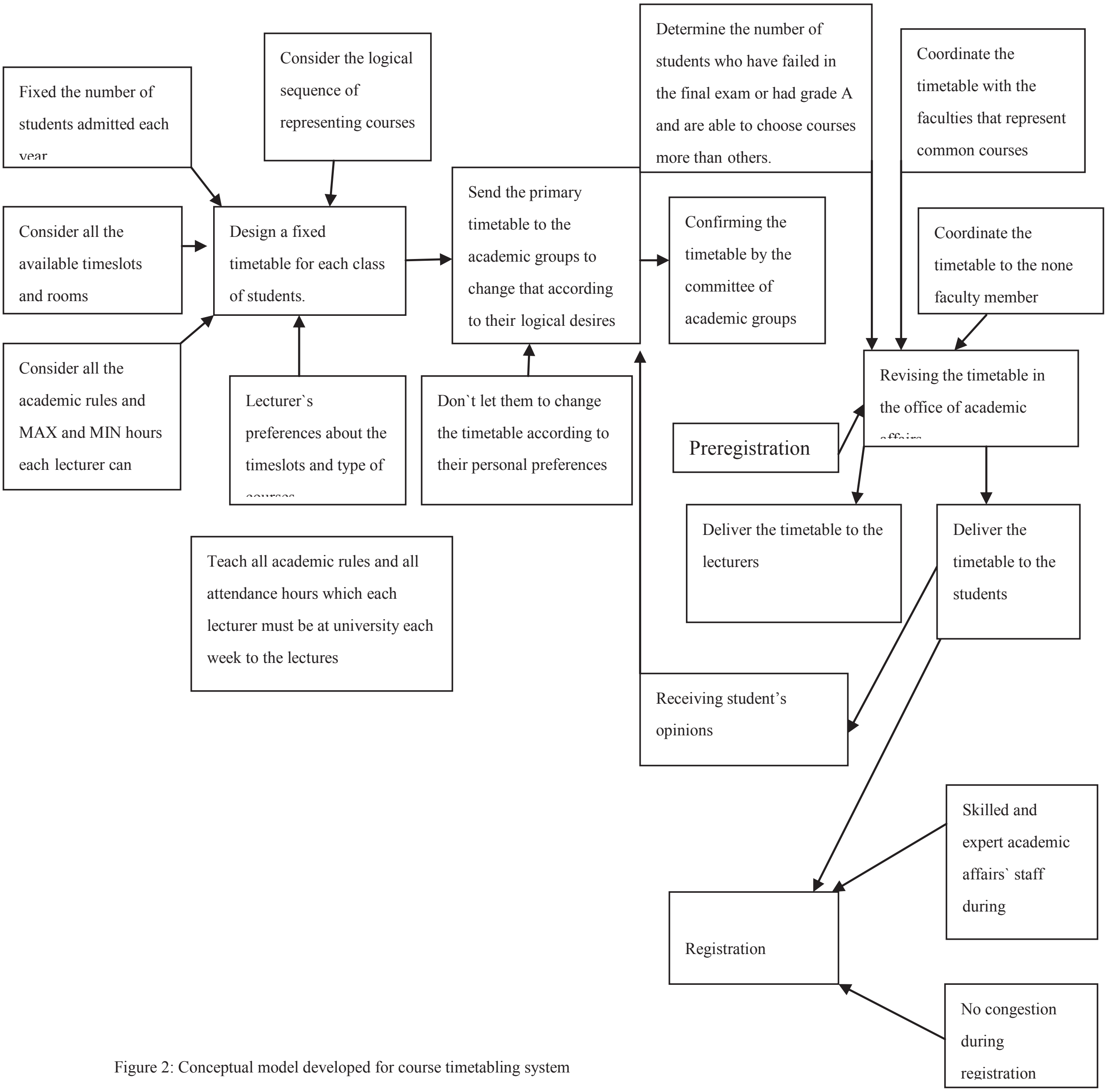

Figure 2: Conceptual model developed for course timetabling system

3.6. Stage 7

This stage involves putting the changes identified in stage 6 in to practice. In our case, before the changes could be implemented they had to be validated by the faculty Dean. The Faculty endorsed the conceptual model and its comparison with the real situation. Furthermore, due to the strategic nature of the mentioned changes, it seems that total results cannot be obtained in the short term period of this research and expected to plan for the future.

4. Conclusion

The soft systems methodology (SSM) targets organizational business and process modeling and identifies unstructured problems as well as identifying non-obvious problem solutions in a holistic view. Specifically, this approach provides the possibility of more clearly capturing the change that is necessary to prepare the ideal university course timetable that will satisfy the concerned people. Applying this methodology to the course timetabling in the management faculty at university of Tehran, shows the potential of SSM for application in the real course timetabling problems.

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