Innovative Applications of O.R.

A heuristic method to schedule training programs for Small and Medium Enterprises

Mahmood Rezaei [a,*], Fahimeh Shamsaei [b], Iman Mohammadian [c], Mathieu Van Vyve [b]

[a] HEC Management School, University of Liège, Belgium
[b] Center for Operations Research and Econometrics, Université Catholique de Louvain, Belgium
[c] Iran University of Science and Technology, Tehran, Iran

ARTICLE INFO

ABSTRACT

During the life period of Small and Medium Enterprises (SMEs) in incubators they need some training programs to acquire the required knowledge in order to survive and succeed in the business environment. This paper presents a heuristic method based on an optimization model to schedule these programs at the most suitable times. Based on the proposed heuristic, each training program is implemented in a suitable time by considering the SMEs' requirements and some other logical constraints. The proposed heuristic is described in detail, and its implementation is demonstrated via a real-life numerical example. The numerical results of the heuristic are compared with other methods.

1. Introduction

Incubators have become an integral part of business in many countries, and governors regard them as a crucial tool in the economic development. The role of Small and Medium Enterprises (SMEs) is not negligible in the boom of every economy, and incubators are one of most effective environments to support SMEs to develop their innovations, commercialize their research results, and achieve a sustainable growth. This support ranges from providing office space and physical equipments with low cost to assistance in developing business plan, capital acquisition, and other specialized services with high added-value (Bergek and Norman, 2008; Grimaldi and Grandi, 2005). The life period of SMEs in an incubator usually takes 24–36 months. After this incubating period, they are expected to become independent with a sustainable development in their business. The early years of the life of SMEs in incubators have been the focus of considerable research effort. Specially, identification of the important factors and conditions that expedite their growth process and success has attracted much attention from the research community. Today's competitive world has diversified the required skills and knowledge to succeed in business. Whereas universities usually provide the preliminary skills from the theoretical point of view, incubators are specialized environments to support SMEs' leaders by providing other necessary

skills and knowledge. Consequently, there exists a gap between the required knowledge and the possessed knowledge by entrepreneurs (Chrisman and McMullen, 2004). The knowledge and skills of SMEs' leaders is very important to increase their performance, competitiveness, and survival chance in the business environment, and it has been argued that SMEs' failures are typically due to the lack of such managerial skills (Feeser and Willard, 1990; Martocchio and Baldwin, 1997; Zahra and Covin, 1993). For any SME to be, and to remain, successful over a long period of time there must be the capability to adapt to new circumstances, especially in the early years of life in an incubator. During the past decade, SMEs have been encouraged to utilize the services of knowledge centers. In spite of these efforts there are still some questions about the nature and the extent of SMEs' knowledge requirements and the efficient ways to transfer this knowledge. However, there is a common agreement on the necessity of continuous training to update and enhance the required skills of employees, and even leaders, in all organizations including SMEs (Salas and Cannon-Bowers, 2001). Implementation of the training programs for SMEs is one of the main duties of incubators (Aaboen, 2009), but it is not a trivial task to choose the right training programs at the right times (Banfield et al., 1996). Our literature survey failed to find many papers directly related to schedule training programs for SMEs. The most relevant research area in the literature is course scheduling, which has attracted the attention of many researchers in the domain of operational research for many years. Course scheduling problems aim to determine which courses should be taught on which days, on what times, and in which rooms, subject to some side constraints (Thompson, 2005).

* Corresponding author. Tel.: +32 42327342.
E-mail addresses: m.rezaei@ulg.ac.be (M. Rezaei), fahimeh.shamsaei@student.uclouvain.be (F. Shamsaei), iman.mohammadian@gmail.com (I. Mohammadian), mathieu.vanvyve@uclouvain.be (M. Van Vyve).

There exist many papers related to the course scheduling problem, and each paper focuses on some specific aspects of this problem. However, the majority of the existing papers have been devoted to course scheduling at universities, where professors are assigned to courses and courses are assigned to time slots and classrooms. Different objective functions might be considered such as conflict in teaching hours, professors' preferences, and continuity of teaching hours. Usually, two types of constraints are defined: those which must be strictly satisfied under any circumstances (hard constraints) and those which are not necessarily satisfied but whose violations should be minimized (soft constraints). Any solution which satisfies all the hard constraints is called a feasible solution. Due to the complexity of the real-world course scheduling problem, the soft constraints may need to be relaxed since it is not usually possible to generate solutions without violating some of them. Soft constraints are usually used within the cost evaluation function to evaluate how good the solutions are (Lu and Hao, 2010). Some exact techniques have been proposed for solving the course scheduling problem, including constraint programming (Valouxis and Efthymios, 2003) and integer programming (Daskalaki and Birbas, 2005). Course scheduling problem is known as an NP-Complete problem. Since NP-Complete problems cannot be solved efficiently as the size of the problem increases (Head and Shaban, 2007) heuristic approaches (Dimopoulou and Miliotis, 2001) as well as meta-heuristics such as ant colony optimization (Azimi, 2005), genetic algorithms (Wang, 2003), tabu search (Alvarez-valdes et al., 2002), and simulated annealing (Zhang et al., 2010) have been extensively applied by researchers to find a near-optimal solution. Although various course scheduling problems and approaches have been investigated in the literature, no specific one can be applied universally due to the specific features of each problem. Some recent works focus to bridge the gap between research and the real world applications (Zhang et al., 2010). In practice, course scheduling is not restricted to universities; many organizations use course scheduling techniques to schedule the required training programs for their employees. These training programs are crucial elements of human resource development in order to follow a sustainable development. They increase the quality of human resources as well as the organizational long term efficiency and productivity. The impact of training programs can be significantly enhanced if they are appropriately scheduled (Juang et al., 2007). Studies conducted in 2006 show that in this year, organizations in the United States spent a total of $55.8 billion on training. However, in spite of such enormous investment in training, there was little evidence of verifiable return or of the effective results (Tharenou et al., 2007). In view of the experts, the main reason of this failure is the lack of needs assessment before implementing the training programs or inappropriate times to implement them. So, both careful *needs assessment* and *in-time implementation* of training programs are necessary to increase the efficiency of the training programs. In other words, the training programs should be implemented not only with a high quality, but also at a suitable time and based on needs assessment. This paper proposes a heuristic method based on an optimization model to specify the most suitable time for implementation of each training program. The remaining of this paper is organized as follows. The optimization model to schedule training programs is presented in Section 2. Then, in Section 3 the proposed heuristic method to find a solution close to the optimal solution of the optimization model is discussed in detail. Section 4 explains an equivalent job scheduling problem in order to show that the application of our problem is not merely restricted to SMEs. A real-life numerical example is provided in Section 5 to demonstrate implementation as well as efficiency of the proposed heuristic. Finally, conclusions and future studies appear in Section 6.

2. Problem statement

The first two or three years of the life of some SMEs is spent in incubators. During this preliminary, and yet vital, period their basic needs should be recognized and supplied by the incubator. In fact, identification and supply of these basic needs is one of the main responsibilities of incubators. The basic requirements of SMEs can be divided into two main parts: hard needs and soft needs. Basic hard needs of SMEs are mostly associated with preparation of different hardware facilities, whereas their basic soft needs consist of the required knowledge to survive and to succeed in the business environment. One of the main duties of incubators is preparation of such knowledge for SMEs.

2.1. The training programs

Training programs are the most common tools in incubators to provide the required knowledge for SMEs. They are effective to enhance personal and organizational capabilities of SMEs in different facets. Indeed, a considerable portion of the required knowledge is provided by training programs. They can also be accompanied by other educational tools, as is common, to supply soft needs. In this paper, we consider the following programs which are usually implemented in incubators (Saidi-mehrabad et al., 2008): (1) managerial principles, (2) business plan, (3) quality management, (4) marketing, (5) product development, (6) capital acquisition, (7) project control and management, and (8) financial management. One can combine some of the above mentioned programs or add some other programs. Here, we do not discuss further about the training programs for two reasons. First, a lot of research has been devoted to determine the appropriate training programs. Second, the proposed heuristic in this paper is independent of the number and the nature of the training programs; so, it can also be used in incubators with different training programs.

2.2. The effective criteria

The key point is that each training program should be implemented at the most suitable time. To this end, it is a good idea to consider the desired value of the criteria based on which performance of an SME is evaluated. According to the experts' opinions (Saidi-mehrabad et al., 2008), the most important criteria to evaluate SMEs are: (1) capabilities of managers, (2) strategic plan, (3) process development, (4) product development, (5) information and advertisement, (6) plan for capital acquisition, (7) scheduling and project control, (8) team working, and (9) costs management. Similarly, because of the two aforementioned reasons about the training programs, we avoid further discussion about the effective criteria to evaluate SMEs. The above criteria have dynamic weights during the life period of SMEs in incubators. For instance, *Information and advertisement* as a criterion is not important in the early months, but it is much more important in the last months. So, a weight function depending on the time, t, can be assigned to each criterion. In addition, there is a correlation between each criterion and each training program. Some of the criteria have a very close relation with a specific training program. However, generally, there is not a one-to-one map between the criteria and the training programs. Indeed, each training program p can improve each criterion c to some extent, and the proposed heuristic is based on this sound idea. For example, the most effective training program to enhance criterion *information and advertisement* is *marketing*; so, the training program *marketing* should be implemented before the last months regarding the desired value of *information and advertisement*.