

Optimisation of engineering education practice resources based on a planning model

Liyuan Cai

Chengdu Technological University
Chengdu, Sichuan, People's Republic of China

ABSTRACT: In order to improve the efficiency of the use of practice resources, a MATLAB simulation model was established based on one of the three models for the allocation of resources in Chinese universities and, specifically, the plan model. This model was based on real data of a practice centre in a university. The simulation results were compared with experiments, and it was proved that the MATLAB simulation model was suitable for optimising the limited practice resources.

INTRODUCTION

In order to carry out the Medium and Long Term Educational Reform and Development Plan Outline (2010–2020) and Medium and Long Term Talent Development Plan Outline (2010–2020), the Ministry of Education of the People's Republic of China put forward a plan for cultivating excellent engineers. The plan emphasises cultivating talent of high quality to meet social need. In order to respond to the plan, Chinese universities offer courses that cultivate excellent engineers. These require an increase in the time taken for practical training and, as a result, great pressure is brought on limited practice resources [1].

To deal with the stress on, and to increase the efficiency of, limited practice resources, one method recognised by many researchers is to establish an open laboratory, in which the equipment, facilities, materials, teachers and locations for practical teaching are managed in a unified manner. However, this method has an adverse effect on the planned use of the practice resources. Guided by data from a university, a feasible solution is presented in this article, by comparing and verifying simulation data with actual data.

DESCRIPTION AND MODELLING OF OPTIMAL ENGINEERING EDUCATION PRACTICE

Description of Optimal Engineering Education Practice

There are mainly three models for the allocation of practice resources in universities in China, viz. the plan model, the reservation model and the hybrid model [2]. The plan model is the simplest, in which practical teaching is carried out according to a schedule [3]. However, this makes it difficult to increase practice teaching. The reservation model involves resources being booked and allocated according to need.

The hybrid model includes the advantages of the plan model and the reservation model. Some resources are scheduled based on the plan model and the rest based on the reservation model. As a result, the hybrid model can improve resource utilisation to meet the needs of practice teaching by better distributing practice resources [4].

In order to solve the difficulty of allocating practice resources, a resource allocation policy is outlined in this article, verified through a MATLAB (mathematical laboratory) simulation. It is assumed in this article that practice resources are adequate since allocation policy is infeasible if practice resources cannot meet needs.

Also, the better the practitioners' satisfaction, the better the allocation policy. Practitioners' satisfaction depends on three factors: the waiting time to get a resource, the time available using the resource and the quality of the resource.

Let $N_i(t_1, t_2, t_3, t_4)$ represent available resources for resource i , where t_1 is the usable hours, t_2 is the resource type, such as milling machine, turning machine, grinding machine, t_3 is the practitioners' identification and t_4 is the resource level. For example, there are two types of punches marked A and B, and two types of stampings marked C and D. The requirement is for C to be higher than D. D can just be completed in a punch marked A, while both C and D can be completed in B.

The term $N_5(13100102, \text{punch}, 20, 4)$ indicates the fifth resource, and means that there are 20 4-level punches in the 2nd period in October, 2013. $R_j(t_1, t_2, t_3, t_4, t_5, t_6)$ represents the demand for resources, where t_1 is the application time for using the resource, t_2 is the starting time, t_3 is the expected time, t_4 is the resource type, which is the same as t_2 in $N_i(t_1, t_2, t_3, t_4)$, t_5 is the priority of the resource (which is different for teachers and students, key projects and independent projects), and t_6 is the applicant.

The term, $R_4(201310111823, 20131101, (11, 12, 21, 22), \text{punches}, 3, 1, 2012010011001)$ is a reference to the person numbered 2012010011001, who applies to use the 3-level punches at 18:23 on 11 October 2013.

Modelling Optimal Engineering Education Practice

In order to build a model, the following four conditions are assumed:

First, if there are enough resources, all demands should be met.

An array (N_i, R_j, C_{ij}) is given, in which C_{ij} equals 0 or 1. $C_{ij} = 1$ means that resource N_i meets the demand R_j , while $C_{ij} = 0$ means that resource N_i does not meet demand R_j . If all demands are met, the following conditions must be obeyed.

- If all demands are met, for any demand j :

$$\sum_{i=1}^n C_{ij} = 1 \quad (1)$$

- The number of resources used should not exceed the total number of resources. For example, if the total number of N_i resource is $N_i(t_3)$ and the number of N_i resource used is $\sum_{j=1}^m C_{ij}$, the following applies:

$$\sum_{j=1}^m C_{ij} \leq N_i(t_3) \quad (2)$$

- The type of both the available resource and demand resource should be same. The condition $R_i(t_4) = N_j(t_2)$ should be met for all resource allocations, which can be expressed as follows:

$$(R_i(t_4) - N_j(t_2)) \times C_{ij} = 0 \quad (3)$$

- For all resource allocations, the condition $R_i(t_5) - N_j(t_4) \leq 0$ should be met. That is to say, the resource level allocated should be equal to, or greater than that requested, which can be expressed as follows:

$$(|R_i(t_5) - N_j(t_4)| + R_i(t_5) - N_j(t_4)) \times C_{ij} = 0 \quad (4)$$

Second, the better the model, the shorter the waiting time.

The average waiting time can be expressed as follows:

$$\left(\sum_{j=1}^m \sum_{i=1}^n (N_i(t_1) - R_j(t_2)) \times C_{ij} \right) / m \quad (5)$$

Third, the better the model, the more the resources are of good quality.

The resource level is $N(t_4)$, and the total resources level is $\sum_{j=1}^m \sum_{i=1}^n (N_i(t_4) \times C_{ij})$.

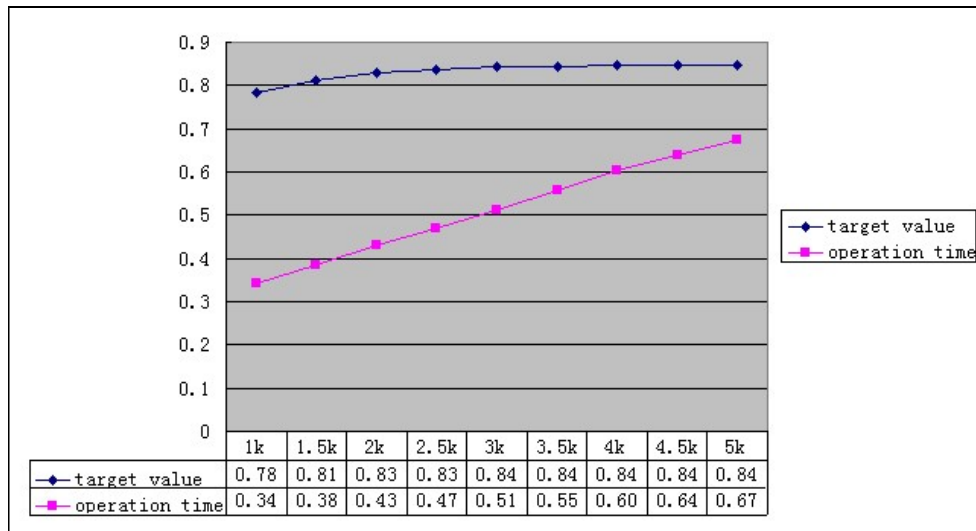


Figure 1: Relationship between the number of operations and the target value, the operation time using the D-algorithm.

It can be seen that the operation time and target value increase with the number of operations (1,000 - 5,000), and the target value becomes stable when the number of operations is beyond 3,000. This indicates that the D-algorithm is feasible.

In order to test if the model can be used to solve larger scale engineering education practice planning problems, the quantity and complexity of the samples were increased. The conditions were as follows: 10,000 students in a certain university, including 7,000 engineering students, and 3,300 hours of courses, including 1,188 hours of practicals. With the help of the MATLAB toolbox, the weekly data for full saturation of 50%, 70%, 80%, 90% were obtained by the simulation analysis. The D-algorithm for 10,000 operations were tested, and the results are shown in Figure 2.

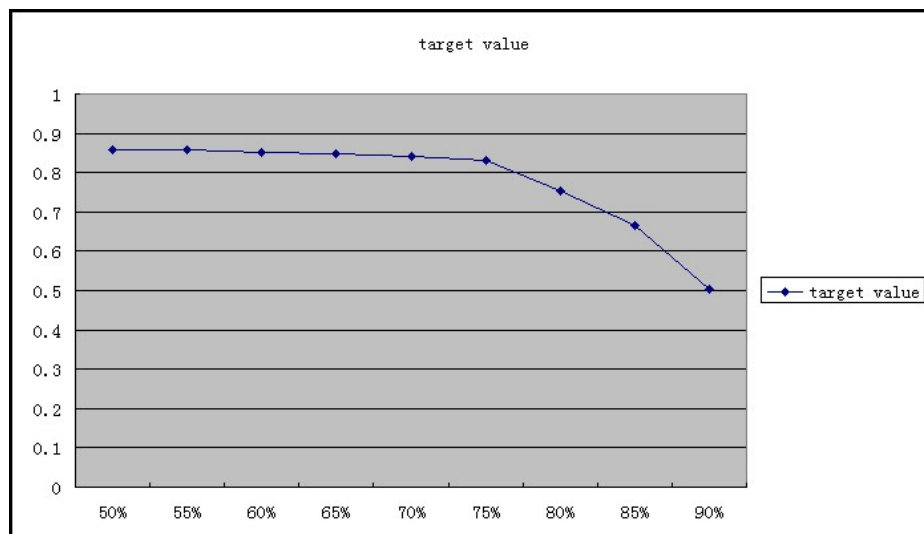


Figure 2: Relationship between the resource saturation and the target values.

It can be seen that the objective value is high when the practice resource saturation is less than 70%; hence, proving that the model is feasible.

CONCLUSIONS

In order to improve the efficiency of the use of limited practice resources, a MATLAB simulation model was developed. The model was based on real data of a practice centre in a certain university. The simulation results were compared with experiments, and it was demonstrated that the MATLAB simulation model was suitable for optimising limited practice resources.

REFERENCES

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