Cultivation of College Students' Innovative Ability in Operational Research Teaching

Min Sun[1, a*], Maoying Tian[2, b] and Hongchun Sun[3, c]

[1] School of Mathematics and Statistics, Zaozhuang University, Shandong, 277160, P.R. China.

[2] Department of Physiology, Shandong Coal Mining Health School, Shandong, 277011, P.R. China.

[3] School of Mathematics and Statistics, Linyi University, Shandong, 276005, P.R. China.

[a]ziyouxiaodou@163.com, [b]hfmaoying@163.com, [c]sunhc67@163.com

Keywords: Innovative ability; Operational Research teaching; Cultivation

Abstract. Originated in the practical problems, Operational Research is a bridge which connects the theories in mathematics with the real world. This enables Operational Research to be a useful tool to cultivate students' innovative ability. In this paper, we discuss some problems encountered in this process and give some suggestions to achieve the goal of cultivation of college students' innovative ability in Operational Research teaching, which can arouse the students' enthusiasm and initiative.

Introduction

Innovative ability is one of the main goals in Operational Research teaching. To investigate students' innovative ability, in the recent teaching of Operational Research, I have arranged the following simple problem to be accomplished by my students: How to understand the paradox about the more you used, the smaller the cost is? To my surprise, all the students answered in chorus: It is impossible and if this is the case, perpetual motion machine will become true. I listened and smiled, and then I gave a real example to help students to understand this paradox.

The student was surprised when they saw the answer I provided. Obviously, I was also surprised by the reaction of the students because students with high knowledge cannot look at problems from multiple perspectives and understand a practical problem according to their knowledge. This gives me a new perspective on the seriousness of the problems existing in the exam oriented education of mathematics in China.

As we all know, Operational Research is an important and basic course for many majors in university, such as science, engineering and economics, etc.[1] Its contents include linear programming, integer programming, graph, gaming and queue. This subject plays an element role in the subsequent courses and students' deeper research, and with the development of the times and the progress of scientific technology, Operational Research plays a more and more in other disciplines. As students enter university, they have to be accustomed to the application oriented Operational Research. During the transition, students have to encounter four main changes: the change from the limit to the infinite, the change from the low dimension to the high dimension, the change from the determination to the random, the change from the concrete to the abstract, which are the main differences of Operational Research and other disciplines. During the learning of Operational Research, the high logic and the strong abstract of mathematical have become increasingly prominent. If teachers cannot adjust students' learning method of Operational Research in time, students will definitely encounter the frustration during their studies of Operational Research.

There is no doubt that [2] the current national higher mathematics teaching is still that teachers give instruction on the platform, and students listen as the audience, and supplemented by examples, explanations, exercises, training and other traditional ways to improve students' academic performance. This kind of teaching method has many shortcomings, which only focuses on examination results and this will undoubtedly reduce students' enthusiasm and interest in Operational Research, and most important, it is not conducive to the cultivation of students'

innovative ability in mathematics. To deal with this issue and to improve the teaching effect, we need to focus on the improvement of teaching ideas, excavate students' pioneering thinking ability, logical thinking ability and divergent thinking ability; improve students' ability to discover problems; master the ability to apply mathematical knowledge to solve the practical problem.

The Cultivation of Students' Innovative Ability in the Teaching of Operational Research

According to the logic and abstractness of Operational Research, the author suggest to improve the teaching of Operational Research from the following angles, so as to improve the creative ability of students in the course teaching.

Recognize and Pay Attention to Mathematical Ideas and Methods

Operational Research education is essentially a kind of quality education, which is an essential component of the competence education. Therefore, the innovative ability is the implementation of Operational Research in one of the important goals of quality education. To make this vision a reality, however, we should put more emphasis on the cultivation of students' learning ability and creative ability in the classroom teaching except the teaching of mathematical knowledge.

The content of Operational Research is full of innovation and it is sustained development. It seems that many theories and methods in Operational Research are quite perfect. However, at the beginning they are often chaotic and even unimaginable. After the hard work of experts in Operational Research, many classical theories are derived and appeared in the textbook. In the process of teaching, the teacher should enable students to experience the whole development of Operational Research's knowledge, from formation to development, and help them to enjoy the pleasures of discovery and creation of knowledge like mathematicians, and improve their interest in studying. Most important, let students understand the ideas and methods of mathematicians to solve problems, and then to cultivate students' creative ability.

The formation of many Operational Research's concepts and conclusions usually contains a wealth of mathematical ideas and methods[3-6]. As we all known that interest is the best teacher and the premise of learning on one's own. Therefore, how to transform the tedious knowledge in Operational Research into interesting results to arouse the curiosity of the students is a big issue for teachers. Based on the previous experience and the character of Operational Research, we suggest to introduce the case teaching into the class, which is application of empirical research in teaching. In fact, based case-teaching we have made many explorations in the teaching reform research and practice of information system analysis and design in recent years. For example, when we taught the graph, we introduced the famous Seven Bridges of Königsberg problem which was solved by the famous mathematician Euler. In the process of Euler solving the problem about seven bridge, we can find out a few ways to solve maths problem. When we taught the assignment problem, we introduced the inventory story of Hungarian method, and we pointed out that Hungarian method is not invented by Hungarian, but an American, who used an lemma proved by one Hungarian to get Hungarian method. From this story, students can learn that cooperation is an important element to reach success.

Highlight the Application of Operational Research's knowledge

People often hope that mathematical teachers can make mathematics to be easily used in every scientific fields, and after learning so much knowledge of mathematics, students should can use these knowledge to solve some easy problems encounter in real life, at least thinking with mathematical logic. Therefore, in the process of Operational Research teaching, we should learn to solve the practical problems we have encountered with Operational Research's knowledge, so that we can learn to be interested and meaningful. If in the classroom teaching we can use some practical problems to train the ability of students, this will undoubtedly stimulate students' learning enthusiasm; inspire students' innovative consciousness and innovative thinking, innovative ability

and innovative personality. In fact, there are many problems related to Operational Research in the famous National Collegiate mathematical modeling contest, such as the D problem in 2003: Crossing the Yangtze River, the B and C problem in 2005: DVD online rental and the D problem in 2016:Analysis and optimization of wind farm operation, etc.

In the following of this subsection, let us use a simple example to illustrate how to apply the abstract knowledge to solve real problem, which is set as a problem for third graders in the town of Bao Loc in the Vietnamese highlands.

Table 1   Fill the blanks

		−		66
+	×	−		=
13	12	11		10
×	+	+		−
:	+		×	:

Problem 1: As is posted in Table 1, you need to fill in the gaps with the digits from 1 to 9 so that the equation makes sense, following the order of operations - multiply first, then division, addition and subtraction last.

Answer: Assume that the binary variable
$$x_{ij} = \begin{cases} 1, \text{ the ith blank is filled with the number } j \\ 0, otherwise \end{cases} \quad (i,j=1,2,...,9) \ .$$

Then, based on the requirement of the problem, we can establish the following mathematical model, which is also an integer programming without objective function.

$$\sum_{j=1}^{9} j \times x_{1j} + 13 \times \sum_{j=1}^{9} j \times x_{2j} / \sum_{j=1}^{9} j \times x_{3j} + \sum_{j=1}^{9} j \times x_{4j} + 12 \times \sum_{j=1}^{9} j \times x_{5j} - \sum_{j=1}^{9} j \times x_{6j} - 11$$

$$+ \sum_{j=1}^{9} j \times x_{7j} \times \sum_{j=1}^{9} j \times x_{8j} / \sum_{j=1}^{9} j \times x_{9j} - 10 = 66$$

$$\sum_{j=1}^{9} x_{ij} = 1 (i=1,2,...,9)$$

$$x_{ij} = 0或1(i,j=1,2,...,9)$$

Solve this simple problem with Lingo, and we can get one of the feasible answer:
$$x_{16} = x_{29} = x_{33} = x_{45} = x_{52} = x_{61} = x_{77} = x_{88} = x_{94} = 1.$$
Then, the nine blanks are filled with 6, 9, 3, 5, 2, 1, 7, 8, 4.

Adhere to the Heuristic Teaching Method

We all hate the rote learning process, but we must understand that any knowledge of learning can not be separated from rote learning. From this point of view, rote learning is a required course in Operational Research, because there are many concepts and algorithms in this curriculum. However, if the teacher adopts the heuristic teaching method, and fully arouses the enthusiasm of the students, and let students really become the subject of teaching activities, then students can not only acquire knowledge in teaching activities, but also get favorable conditions for the development of their abilities. Therefore, an important task for the teacher who are teaching this curriculum is to inspire students to take the initiative to analyze problems and solve problems independently, and simplify these dull and turgid knowledge. In this subsection, let us use an example to illustrate the importance of heuristic teaching method.

Problem 2: One production line needs to work day and night. Workers on the production line first work 4 hours, then rest 2 hours, then continue to work 4 hours and go off work. After they rest 14 hours, they go to work again. Now, the production line needs 596(people*hour) during 8:00 am to 12:00 am, 304(people*hour) during 12:00 am to 2:00 pm, 492(people*hour) during 2:00 pm to 6:00 pm, 366(people*hour) during 6:00 pm to 10:00 pm, 202(people*hour) during 10:00 pm to 12:00 pm, 412(people*hour) during 12:00 pm to 4:00 am, 404(people*hour) during 4:00 pm to 8:00 am. Furthermore, to maintain the continuity of the production line, at least one team need on duty to take care of the key process in the production.

Answer: This problem is a little complicated due to so many time intervals. Then we can assume the following variables. Let x1 mean the number of workers who go to work on 8:00 am; x2 mean the number of workers who go to work on 12:00 am; x3 mean the number of workers who go to work on 2:00 pm; x4 mean the number of workers who go to work on 6:00 pm; x5 mean the number of workers who go to work on 10:00 pm; x6 mean the number of workers who go to work on 12:00 pm; x7 mean the number of workers who go to work on 4:00 am. Then, to get a clear relationship among these seven variables, we can plot the following table, in which √ means these workers are working during these time intervals.

Table 2 The crossing relationship

	8-10	10-12	12-14	14-16	16-18	18-20	20-22	22-24	24-2	2-4	4-6	6-8
x1	√	√		√	√							
x2			√	√		√	√					
x3				√	√		√	√				
x4						√	√		√	√		
x5								√	√		√	√
x6	√								√	√		√
x7		√	√								√	√

Using this table, we can establish the following mathematical model of the problem.

$$\min Z = \sum_{i=1}^{7} x_i$$

$$s.t. \begin{cases} 4x_1 + 2x_6 + 2x_7 \geq 596, 2x_2 + 2x_7 \geq 304 \\ 4x_1 + 2x_2 + 4x_3 \geq 492, 4x_2 + 2x_3 + 4x_4 \geq 366 \\ 2x_3 + 2x_5 \geq 202, 4x_4 + 2x_5 + 4x_6 \geq 412 \\ 4x_5 + 2x_6 + 4x_7 \geq 404, x_1 + x_5 \geq 1 \\ x_1 + x_7 \geq 1, x_2 + x_7 \geq 1, x_i \in Z^+, i=1,2,3,4,5,6,7. \end{cases}$$

This integer programming can be solve by Lingo software easily:

```
Min=x1+x2+x3+x4+x5+x6+x7;
      4*x1+2*x6+2*x7>=596;
      2*x2+2*x7>=304; 4*x1+2*x2+4*x3>=492;
      4*x2+2*x3+4*x4>=366;2*x3+2*x5>=202;
      4*x4+2*x5+4*x6>=412;4*x5+2*x6+4*x7>=404;
      x1+x6>=1;x1+x7>=1;x2+x7>=1;
    @gin(x1);@gin(x2);@gin(x3);@gin(x4);@gin(x5);@gin(x6);@gin(x7);
end
```

Summary

In this paper, we have discussed the methods to cultivate the innovative ability of college students in Operational Research. Several suggestions are provided according to the authors' previous experience, which have been verified in practice.

Acknowledgement

References

[1] Zhjyan Zhou, The problem is the true soul of creative education in Advanced Mathematics, Engineering Mathematics, 18(3) (2002) 69-71.

[2] Zhiguang Zhang, Training students' innovative application ability in Higher Mathematics Teaching, Journal of Chifeng University (NATURAL SCIENCE EDITION), 28(6) (2012) 245-246.

[3] Daqian Li,The mathematical modeling thought is integrated into the main course of Mathematics, Journal of Engineering Mathematics, 22(8) (2005) 3-7.

[4] Hualong Jiang, The reformation of high education's teaching model based on the cultivation of innovative intellect, Education of Modern University, 5 (2007) 102-105.

[5] Xiaofeng Fang, How to cultivate students' innovative ability based on the teaching of advanced mathematics, Mathematics of University, 10 (2010) 57-61.

[6] Chongwen Wang, The cultivation of students' innovative ability based on the character of advanced mathematics, Science Education of High School, 4 (2007) 10-13.