Exploration on construction of engineering management related courses based on outcome-based education model

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Abstract. China’s engineering education system is experiencing a transition from research to application or practice. Professional accreditation emphasized the importance of engineering management course to share views and experiences in engineering management. Based on the preparation process for China Engineering Education Accreditation, this research adopts the outcomes-based education model to explain the construction of engineering management related courses in order to achieve better results, competencies, objectives and requirements for students. Regarding the current education development status, the directions for how to successfully apply outcomes-based education ideas into the whole period of campus life are also suggested for the discipline of mining engineering.

1. Introduction
Outcome based education, hereafter OBE, is an advanced educational concept. It was firstly introduced by Spady in 1981 and its EC2000 standard was issued in 1997 by the American Association for Educational Accreditation (ABET), which indicates that the OBE concept will be gradually accepted by the world. It has become the mainstream idea of education reform in the United States, Canada, Britain and other countries. The key point of OBE is to help students achieve learning outcomes. However, the accreditation of OBE concept started late in China. Since the implementation of the 2015 edition of Engineering Education Accreditation Standard, the concept of OBE has developed rapidly. At this stage, the concept has been continuously strengthened, which is of great significance to the development of China’s education [1].

There are numerous researches on the application and possible influences of outcome based education on the current education pattern. Eng et al. (2012) investigated the impact of the OBE implementation by incorporating technology innovation in Malaysia, and concluded that the teaching and learning of a higher education institution should pay more attention to the efficiency of OBE implementation [2]. Tan et al. (2018) discussed the effectiveness of OBE model among the nursing students and investigated the ways of enhancing the competencies of these students [3]. Jamkhandikar and Jamkhandikar (2016) researched the possible implication of OBE model incorporating technology innovation in the higher education institution in Malaysia [4].
Engineering management related courses are one of the main courses, which are established by the major of mining engineering. For example, project budget and management is designed for mining engineering and industrial engineering. Previous courses for project budget and management include Systems Engineering, Professional Introduction (Mining Engineering), and Professional Introduction (Industrial Engineering). Through the learning of this course, students will have the ability to make decisions and analyze general engineering projects. This paper introduces the construction of engineering management courses by using OBE concept in the field of mining engineering.

2. OBE model for building engineering management courses in the major of mining engineering

2.1. Design outcome-based objectives for engineering management courses

OBE adopts the idea of reverse design when setting courses objectives, which mean that we should determine the objectives from the needs, and then decide the requirements and knowledge abilities that students need to master in the final graduation according to the objectives, and finally confirm the indicators by the graduation requirements [5]. Table 1 demonstrates the supportive degree of engineering management courses to the requirements of mining engineering graduate. The implementation is forward because the graduation requirements support the objects, and the courses system supports the graduation requirements, and the courses objectives support the indicators of graduation requirements.

**Table 1. Supportive degree of engineering management courses to mining engineering graduate**

| Course Objectives | Graduation Requirements                                                                 | Intensity |
|-------------------|----------------------------------------------------------------------------------------|-----------|
| Goal 1            | Under the constraints of social, health, safety, law and culture, we can identify and understand the basic principles of mining engineering practice and the background factors affecting engineering disciplines, and understand the responsibilities we should assume. | Low       |
| Goal 2            | Understand the principles of project management and economic decision-making methods of mining engineering related projects. | Low       |
| Goal 3            | Understand the principles of project management and economic decision-making methods of mining engineering related projects. | High      |
| Goal 4            | Employ management and economic decision-making methods to design and develop mining engineering solutions in a multidisciplinary environment. | Medium    |
| Goal 5            | Understand the principles of project management and economic decision-making methods of mining engineering related projects. | Medium    |
|                   | Employ management and economic decision-making methods to design and develop mining engineering solutions in a multidisciplinary environment. | High      |

The engineering management courses in the area of mining science focus on cultivating students’ ability to analyze and make decisions on engineering projects and to solve various problems under different conditions by use of management and economic decision-making methods.

2.2. Education process with OBE concept

The teaching process is the best way to combine OBE concept with practice. Compared with traditional education, OBE has some differences, which are manifested in the following aspects.

First, the concept of OBE model is more open, focusing on guiding students, emancipating the mind and stimulating their creativity. More emphasis is given on cooperation rather than competition.
in learning. The students could achieve the final results through collaboration, not only favorable for self-development, but also helpful for others to improve. For example, group discussion in the classroom can enable students to express their opinions and learn widely from others’ strong points, which not only deepen their understanding of knowledge, but also obtain others’ opinions on their own knowledge. This is important for engineering management classes because of many case studies in exploration and the feature of open-question-oriented design.

Second, OBE model focused on the integrity of knowledge. Traditional education pattern divides knowledge into units and makes explanations convenient, but this also weakens the integrity of the knowledge system. The OBE concept strengthens the links between chapters, which enable students to have a more comprehensive understanding of the whole knowledge system and improve learning efficiency. Systematic view on the engineering management classes is very important for the student to figure out the relationships between these engineering management courses.

Third, the teachers should pay attention to the combination of teaching and learning. In order to avoid the deficiency of traditional education, teachers should determine the content and methods of teaching by the OBE concept, emphasizing students’ ability improvement. The student-centered model makes teachers and students to establish an equal and cooperative relationship. For example, project budget and management course should decide the total budget, which could be suggested by the students and then ask their solution for this question.

Fourth, we should emphasize the importance of practice. To combine theoretical knowledge in the classroom with practice, we not only emphasize the innovation of knowledge, but also ignore the practicality of knowledge. We should encourage students to practice how to decide the project team, and find the suitable methods to solve problems, so as to improve their comprehensive understanding.

In the course of engineering budget and management, teaching accounts for the vast majority of time. With the question-and-answer and homework exercises, students’ ability will be limited. Students should be encouraged to find specific mining engineering projects to understand the project quota, and to arrange project budget and to maintain project process. With the mining characteristics, the department should build internship agreement with mining company to enable students to participate in the real project. Thus, the student could feel the sense of achievement of solving practical problems with the knowledge they have learned, and stimulate students’ enthusiasm for their major of mining science.

2.3. Diversification evaluation system

There are many methods for course evaluation, and different evaluation methods produce different evaluation results. The traditional evaluation method is based on the average of the students’ scores. In order to judge the students’ mastery of the course, the teachers must understand the completion of teaching objectives, the examination results, the classroom performance, homework completion and other factors. This method is a general method of examination courses, and also a necessary evaluation for teachers. However, OBE is different from the above comparative evaluation. It focuses on self-comparison. It does not emphasize whether or not it has been improved compared with other students. Therefore, the evaluation results are not comparable, but students’ self-evaluation has certain reference value for the achievement of courses objectives.

At present, the assessment of engineering management courses is based on the proportion of 70% for final examination and 30% for ordinary performance to get the final results. The regular grades are measured by their attendances and behaviors in class, grades for experiment reports and classroom tests. Because the OBE evaluation belongs to non-comparative evaluation, it cannot directly get the goal attainment degree and the OBE evaluation could be integrated in the above evaluation. Self-evaluation and group evaluation are added to the normal grades. This can not only make an intuitive comparison, but also understand each student’s self-perception, so as to obtain a more objective and fair understanding for the completion of the curriculum objectives.
2.4. Undergraduate tutorial system and education management

A good management system can effectively promote the improvement of teaching quality [6]. At present, there are still more or less problems in the educational management system of many universities in China, such as imperfect management mechanism, unclear management responsibility, or inadequate improvement of the system, which limit the improvement of education quality. Three measures can be taken to reform the management system. The project budget and management course is taken as an example to demonstrate how to implement education management principles in the whole process of teaching.

(1) The idea of continuous improvement should be adopted. OBE adopts the concept of continuous improvement in the construction of management system [7]. This is a long-term and effective mechanism, which can be continuously improved. The results of each improvement can be compared with the previous one to determine where there is progress, where still need to be improved. As for the specific factors affecting curriculum objectives achievement, measures should be taken to promote the continuous improvement of teaching quality.

(2) Perfect organization and clear responsibility is need. Schools should set up efficient quality management organizations to implement their responsibilities to individuals and to ensure smooth operation of quality management work. There must be a corresponding responsibility network for solving problems.

(3) The governor should adopt the theory of total quality management. Schools should also implement total quality management (TQM), and make statistics on all factors that may affect the quality of teaching. Finally, we could formulate corresponding strategies according to the statistical results, and then strictly monitor the implementation of the whole process. Therefore, all factors affecting the quality of teaching are always in the state of monitoring [8]. TQM would ensure the stability of teaching quality.

The above-mentioned management system is enacted with the undergraduate tutorial system in our university. The tutor is responsible for the students as a guiding and supervisory role in the process of students’ learning, training for innovation and entrepreneurship, and academic research. This can not only help students better complete their learning tasks, but also provide a reliable guarantee for the improvement of teaching quality.

3. Possible outcomes from the transition to OBE pattern

This research mainly focuses the courses in the field of engineering management, which are project budget and management, management and evaluation of engineering project, basic theory of project decision-making. These three classes are the major management courses for the discipline of mining engineering. This section analyzes the possible achievements from the implementation of OBE model in engineering management related classes.

3.1. Qualification for International Project Manager Professional (IPMP)

International Project Manager Professional is the certification recognized as a professional project manager by International Project Management Association (IPMA). As shown in Figure 1, there are four levels, named as A, B, C, D, in its system, where IPMA level A means the highest level for very experienced and competent project, programme and portfolio managers certification and IPMA level D is the least requirement certification for certified project management associate.

At the regional level, Project Management Research Committee (PMRC) of China is the representative of China’s membership in this union, which is under supervision of Chinese Society of Optimization, Overall Planning and Economical Mathematics. As shown in Figure 1, PMRC is made up of many committees, sole authorization, and cooperation center for certification. Huading project management is responsible for the project management software development. The class of management and evaluation of engineering project is designed for this qualification. And project management software practice should be added in the class as an indispensable part for the certification exam of PMRC.
3.2. Qualification for China’s professional certificates
Cost engineer is one of the standard certificates in China’s professional technician management system. It is held in around October every year. Cost engineer certification contains two levels and you should pass four different types of exams. The exam for Level 2 should have a Level 1 certificate. The class of project budget and management is suitable for the training class of this national qualification.

3.3. Academic competitions and project management knowledge contest
There are numerous national academic competitions. Among them, national project management competition for college students is supervised by Project Management Research Committee in Figure 1. The team is made up by four students and there are team score and personal score in this competition. Personal score above 110 points could be used for the application of IPMP D level certification.

4. Conclusions
OBE model is an indispensable part of the current teaching mode in colleges and universities, which is of great significance to the course construction and reform. Based on the elaboration of the engineering management related courses, this paper analyses the possible application of OBE theory in these courses from the setting of course objectives to the improvement of management system. Compared with the traditional education concept, the OBE concept shows a strong adaptability and reveals its absolute superiority in the personnel training aspect [9]. Under the guide of Spady (1981) [10], the application of OBE concept has greatly promoted the development of education in China, and has also promoted the reform of engineering education.

This paper presents an optional OBE-based construction strategy for engineering management courses which is suitable for the field of mining engineering. It is also committed to combining the discipline characteristics of China University of Mining (Beijing) into this design. Under the guidance of “World First-Rate Discipline Construction University” initiative and Double Ten Thousand plan, we should maintain the specialty of mining engineering as the advanced engineering subject and create senior the professional engineers full of mining engineering technology and equipped with engineering management knowledge.
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