Teaching Reform for the Optimized Design Theory and Method Course Based on the OBE Concept and Power Index Method

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Abstract. The essential requirement of the OBE concept is to focus on the overall development of students and the needs of their jobs. Therefore, this paper proposed a brief analysis of the teaching reform for the optimized design theory and method course based on the Outcomes-Based Education concept *and* power index method. Firstly, we analyzed the problems in the teaching of this course. Secondly, the power index method is proposed to evaluate the optimization design theory and method course. Finally, the teaching reform of the optimized design theory and method course is presented based on the above evaluation method. The above results can provide reference value for teaching reform of other courses.

Keywords: Outcomes-Based Education · teaching reform · OBE Concept · power index method

1 Introduction

Outcomes-Based Education (OBE) was proposed by Professor Spady in 1988 1, and a series of results were formed in 1994 and used in teaching 2. The OBE philosophy mainly includes three aspects: learning output as the core, outcome-oriented, and student-centered. The essential requirement of the OBE concept is to focus on the overall development of students, to satisfy the needs of their jobs, to accomplish this learning outcome, and to achieve the teaching goal of improving students' abilities.

The teaching concept of OBE has been widely used at home and abroad. For example, the Pakistan Engineering Council (PEC) stipulates that OBE must be implemented in all engineering degree courses in undergraduate education 3. Dr. Katherine T. from the Faculty of Medicine, University of Malaya, put forward the teaching reform of nursing courses based on the concept of OBE, and explained the role and advantages of OBE in nursing teaching reform by analyzing the learning outcomes of nursing courses 4. In recent years, a series of research has been carried out in China based on the OBE concept. By querying and searching for OBE keywords in How Net, the application status of the OBE concept in various disciplines is obtained (as shown in Fig. 1). It can be seen from the figure that the OBE concept is the most widely used in higher education disciplines, accounting for 42.02% of the disciplines, followed by computer software and computer applications, accounting for 8.85%, and vocational education, accounting for 6.21%.

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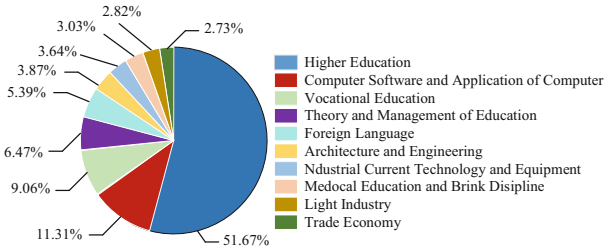

Fig. 1. Current status of the application of OBE concepts in various disciplines *(Data comes from CNKI)*

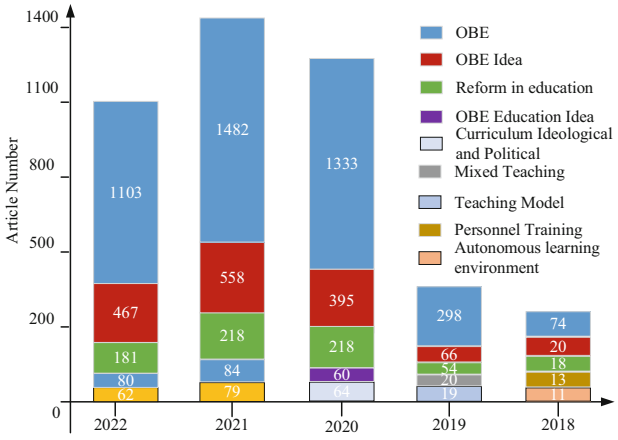

Fig. 2. The number of published papers on OBE education concepts *(Data comes from CNKI)*

It can be seen from Fig. 2 that in the past five years, the main research direction of most scholars is OBE and OBE concept, followed by teaching reform, and the third is the combination of OBE and blended teaching for curriculum teaching reform and practice.

Further, through the analysis, the number of articles published on the OBE education concept from 2018 to 2022 can be obtained, as shown in Fig. 2. Further through the literature search and analysis of the course research and teaching reform of "Optimized Design Theory and Method", the number of papers published in this course research is shown in Fig. 3 and Fig. 4, respectively.

As can be seen from Fig. 3 and Fig. 4, there are still some problems in the current "Optimized Design Theory and Method" course worthy of study, and it is also an important direction in teaching reform.

Based on the above analysis, it is reasonable and feasible to carry out curriculum teaching reform based on the OBE concept. Therefore, this paper studies the teaching reform of "Optimized Design Theory and Method" based on OBE, in order to solve the common problems existing in the teaching process of "Optimized Design Theory and Method" for the professional course of military equipment science. From the four

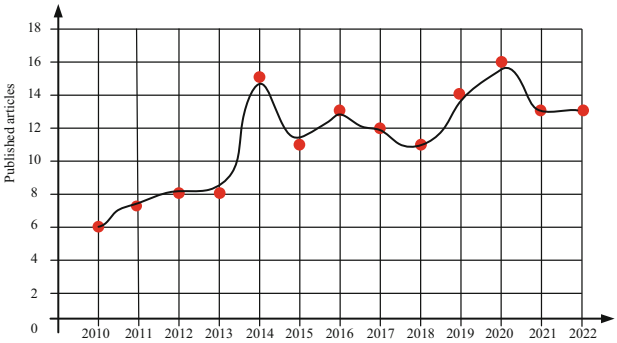

Fig. 3. Publishing trend of research papers in the course "Optimization Design Theory and Methods" *(Data comes from CNKI)*

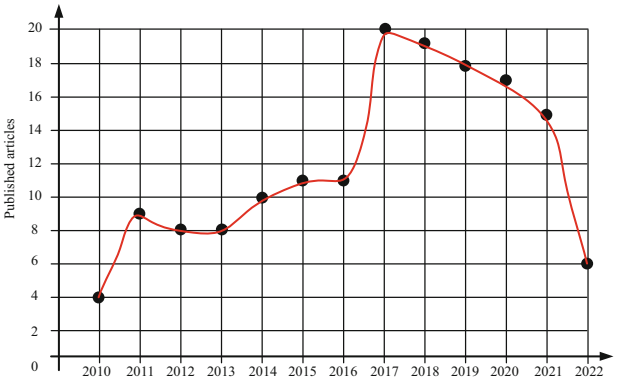

Fig. 4. Publishing trend of research papers in the course "Optimization Design Theory and Methods" *(Data comes from CNKI)*

aspects of adjusting the course teaching objectives, teaching activities, teaching ideas and optimizing the assessment and evaluation, the student's theoretical and practical ability will be improved, and the construction of the military equipment science course will be further promoted to meet the needs of the armed police force equipment and related positions.

2 Problem statement of the Optimized Design Theory and Method Course

"Optimization Design Theory and Method" is a course that combines optimization theory and computer technology to provide designers with scientific design methods. Based on the method of optimal design theory, designers can quickly find the optimal or sub-optimal design solution from multiple design solutions by using a computer, which can improve design quality and work efficiency. Therefore, the optimal design theory is widely used.

The optimization design theory and method course is a professional course for military equipment majors, which enables students to understand a variety of optimization design methods and the latest intelligent optimization methods. It is possible to design and transform police equipment with the optimal design method, promote the improvement of students' overall quality, and provide corresponding theoretical guidance for students' future high-tech equipment design research to improve work efficiency. This course is very practical, and according to the newly revised talent training plan, the teaching objectives, content, methods, experimental courses and assessment methods of this course have all undergone new changes.

According to the author's own teaching practice, it is found that this course has the following three problems:

2.1 The Theoretical Basis Teaching and the Cultivation of Applied Ability are out of Touch

According to the characteristics of this course, because it involves more comprehensive knowledge such as mathematical theoretical knowledge, optimization algorithm and software program development, students are more afraid of difficulties, less interested in learning, and lack of internal motivation. Students cannot easily master basic theories and algorithm principles, resulting in a low level of application of optimization methods.

2.2 The Contradiction Between Course Content and Technological Development is Prominent

After years of development, optimization design theory and methods have gone through the development stage from classical optimization methods to modern optimization methods. The current textbooks are mainly based on classical optimization methods. The course content does not match its technical field.

2.3 Theory and Engineering Application do not Match

A single knowledge training does not match the comprehensive ability required for engineering application. How to combine the optimization method with the existing weapons and equipment of the army, and how to find a better solution among multiple solutions are the problems that need to be solved urgently when the theory of this course is combined with practice.

3 The Power Index Method for the Optimization Design Theory and Method Course Evaluation

To solve the above-mentioned problems in the optimization design theory and method course, a new course evaluation method is proposed for the optimization design theory and method course based on the power index method.

3.1 Construction of Evaluation Index System of the Optimization Design Theory and Method Course

At first, the optimization design theory and method course evaluation index system is constructed based on the OBE concept, as shown in Fig. 5.

3.2 Calculation of the Optimization Design Theory and Method Course Evaluation Index and Their Corresponding Weights

Since the evaluation index in Fig. 5 are qualitative indicators, it can be calculated by the fuzzy comprehensive evaluation method 5. Usually, the fuzzy comprehensive evaluation method applied in this paper can be described as follows.

Step 1. Establish the remark set , and the value of the remark set is $V = \{11, 9, 7, 5, 3, 1\}$.

Step 2. Construct the score set. According to the questionnaire survey, we have

$$\boldsymbol{X} = \begin{array}{c} \\ E_1 \\ E_2 \\ \vdots \\ E_m \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \end{array} \tag{1}$$

where $C_1, C_2, \cdots, C_n$represent the evaluation index; $E_1, E_2, \cdots, E_m$ stand for the expert; m and n are the number of experts and index, respectively.

Step 3. Calculate the evaluation index value. According to the Eq. (1), we obtain the i-th index is

$$x_i = \frac{1}{m} \sum_{k=1}^{m} x_{ki} \tag{2}$$

where $k = 1, 2, \cdots, m$

Furthermore, the weight of the optimization design theory and method course evaluation index is usually calculated by the fuzzy analytic hierarchy process (FAHP) method 6, which is shown as follows.

Step 1. Establish the following fuzzy comparison matrix

$$\boldsymbol{R} = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_2 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_2 \end{array} \\ \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1} & r_{n2} & \cdots & r_{nn} \end{bmatrix} \end{array} \tag{3}$$

where r_{ij} represents the comparison between the index i $i$and j j, which satisfying the following formula.

$$\begin{cases} 0 \le r_{ij} \le 1 \\ r_{ij} + r_{ji} = 1 \end{cases} \tag{4}$$

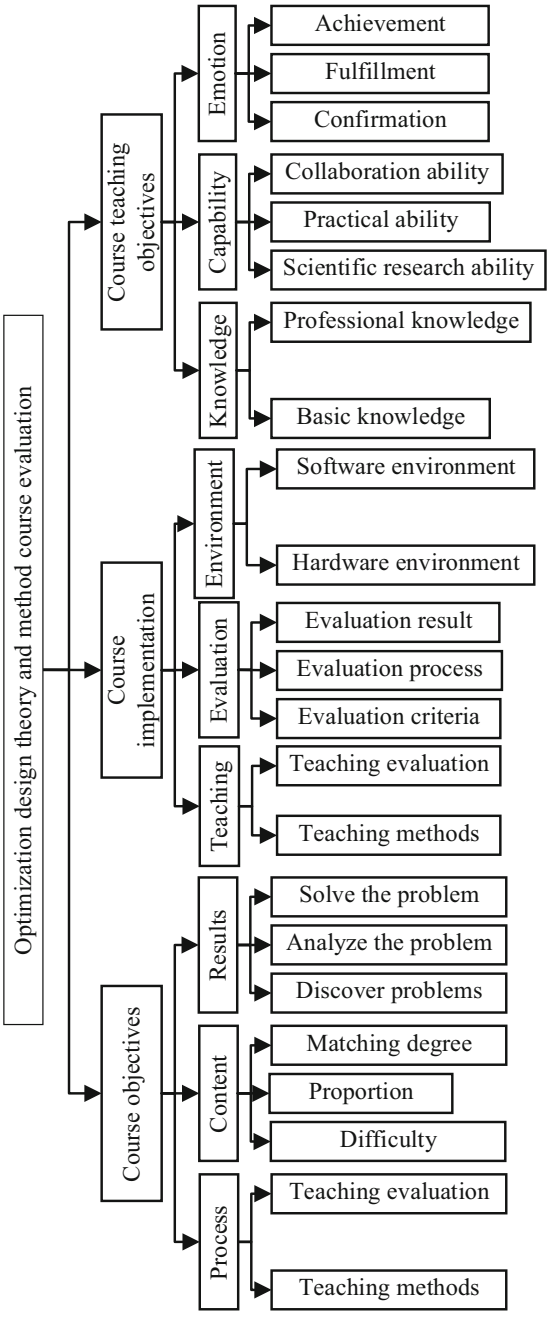

Fig. 5. Evaluation index system

Step 2. To ensure that the above fuzzy comparison matrix meet the consistency conditions, it needs to be modified by the following equation, i.e.,

$$r_{ij}^{*} = \frac{\sum_{k=1}^{n} r_{ik} - \sum_{k=1}^{n} r_{jk}}{n} + 0.5 \tag{5}$$

So, we have

$$\boldsymbol{R}^{*} = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_2 \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_2 \end{array} \\ \begin{bmatrix} r_{11}^{*} & r_{12}^{*} & \cdots & r_{1n}^{*} \\ r_{21}^{*} & r_{22}^{*} & \cdots & r_{2n}^{*} \\ \vdots & \vdots & \ddots & \vdots \\ r_{n1}^{*} & r_{n2}^{*} & \cdots & r_{nn}^{*} \end{bmatrix} \end{array} \tag{6}$$

Step 3. the weight of the optimization design theory and method course evaluation index is given as follows:

$$w_i = \frac{1}{n} - \frac{1}{n-1} + \frac{2\sum_{j=1}^{n} r_{ij}}{n(n-1)} \tag{7}$$

3.3 Evaluation Model of the Optimization Design Theory and Method Course Based on the Power Index Method

According to Eqs. (2) and (7), the evaluation model of the optimization design theory and method course is proposed by the power index method, i.e., 7, 8

$$P = (x_1)^{w_1}(x_2)^{w_2} \cdots (x_i)^{w_i} \cdots (x_n)^{w_n} \tag{8}$$

4 The Teaching Reform of the Optimized Design Theory and Method Course

After using the above evaluation methods to evaluate the optimization design theory and method course, we suggest that teaching can be improved from four aspects 9–11.

4.1 Adjusting the Teaching Objectives of the Course

Based on the concept of OBE, the emphasis is on the cultivation of students' abilities, not limited to the mastery of knowledge. Therefore, the teaching objectives of the course are shown in Table 1.

Table 1. Ability training goals of "Optimized Design Theory and Methods"

Competency Element	Professional Ability	Independent learning Ability	Collaborative Communication Skills
Curriculum Ability Training Requirements	Quickly and proficiently master the use of MATLAB and Visio software	Possess independent learning ability	Possess teamwork communication skills
Talent training program requirements	Possess solid professional theoretical knowledge	Possess independent learning ability	Possess teamwork communication skills
Requirements for Hiring Units in the Army	Quickly master a multimedia tool	Have the ability to learn new knowledge at any time	Leadership and commanding ability

4.2 Adjustment of Teaching Activities

In view of the above teaching objectives, the teaching activities are adjusted as follows.

1) **Realize the combination of theoretical foundation and application ability training**

In view of the problem that students are more afraid of difficulties and less enthusiastic about learning due to the high requirements of mathematics basics in the teaching of this course, in terms of knowledge points such as the basic theory of the course, we strive to use some classic examples to vividly show the application examples of theoretical knowledge. In terms of algorithms, it focuses on enabling students to master the ability to use existing mathematical tools to solve practical engineering application problems, and further improve the application level of students' theoretical knowledge.

2) **Combining course content with equipment optimization and development**

With the development of science and technology, optimization methods have also developed from traditional optimization methods to multidisciplinary design optimization, intelligent optimization methods and other related fields. Combining the content of this course with the development of equipment optimization technology, applying the learned classical optimization methods and modern optimization methods to the field of equipment optimization and development, to solve the problems that need to be solved urgently in the development of weapons and equipment, so that students have a sense of achievement and achievement, and then stimulates students' inner learning motivation, laying a technical foundation for subsequent scientific research and academic research.

4.3 Adjustment of Teaching Ideas

This course is divided into the basic theory of optimization design method and the development frontier of intelligent optimization method from the perspective of knowledge

structure; From the organizational structure, it can be divided into basic theory, computer operation and lectures. For the basic theory, students can master the basic knowledge of optimization design methods, such as the basic theory of optimization methods, unconstrained optimization methods, constrained optimization multi-objective optimization methods; Furthermore, students can express the optimization design method with computer programs and apply it to the design and transformation of police equipment by the computer operation; Finally, students can understand the development status of intelligent optimization methods and carry out classroom discussions to mobilize students' enthusiasm for learning, cultivate students' creative thinking and ability to actively analyze and think about problems, so as to lay a solid theoretical foundation and cultivate good technical skills for future jobs in police equipment 12–14.

4.4 Optimizing Assessment and Evaluation

1) **Overall evaluation of the course**

The course assessment should focus on assessing students' ability to comprehensively master the theory and method of optimization design while examining basic theories. So, the course grades S mainly includes the theoretical grades S_t and usual grades S_u, i.e.,

$$S = 0.6 \times S_t + 0.6 \times S_u \tag{9}$$

2) **Staged achievement evaluation**

As shown in Table 2, emphasis is placed on the cultivation of students' abilities in course learning, especially the results of students' independent learning, teamwork results and writing skills directly determine the students' usual learning results.

Table 2. Proportion of staged evaluation

Serial	Project	Details	Proportion
1	Classroom Performance	Classroom Speech	10%
2	Paper Reading	The Number of Literature Read	10%
3	Visio Software	Visio Flowchart	15%
4	MATLAB Software	Algorithm Program	25%
5	Writing the Thesis	Course Paper	30%
6	Reply	Thesis Defense	10%

5 Conclusions

To solve the problems in the teaching of the optimization design theory and method course, this paper proposed a brief analysis of the teaching reform for the optimized design theory and method course based on the Outcomes-Based Education concept *and* power index method.

1) Firstly, we analyzed the problems in the teaching of this course, which mainly includes three problems, i.e., the theoretical basis teaching and the cultivation of applied ability are out of touch; The contradiction between course content and technological development is prominent; Theory and engineering application do not match;
2) Secondly, the power index method is proposed to solve the above-mentioned problems in the optimization design theory and method course evaluate the optimization design theory and method course. At first, the optimization design theory and method course evaluation index system is established by the OBE concept. Second of all, the optimization design theory and method course evaluation index and their corresponding weights are calculated by the fuzzy comprehensive evaluation method and fuzzy analytic hierarchy process, respectively. Finally, the evaluation model of the optimization design theory and method course is proposed by the power index method.
3) Thirdly, based on the concept of OBE, this paper analyzes the teaching reform ideas and measures of "Optimized Design Theory and Method" from four aspects: adjusting the teaching objectives of the course, adjusting the teaching activities, adjusting the teaching ideas and the ideological and political modules of the course.

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