

Research on Evaluation and Analysis Model of Graduation Attributes Attainment

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Abstract: This article reveals a meta-analysis on the evaluation of the graduation attributes attainment for 22 domestic and foreign universities. Common problems can be concluded into the following four aspects: 1. Compared with the technical graduation requirement index points, the descriptions of non-technical index points were vague, and the measurability was generally poor. 2. The weight setting between different courses supporting the same index point was generally subjective. 3. According to the “Wooden Barrel Short Board Principle,” single use of the lowest value of the index points usually covered up the attainment of other index points of the similar graduation requirement. 4. The lack of information support in each section of the graduation attributes evaluation could result in heavy workload, low efficiency and weak teacher initiative. Based on the 12-year experience of engineering educational reformation in Dalian Neusoft University of Information (DNUI), this article proposes an evaluation and analysis model of graduation attributes attainment, on the basis of TOPCARES, supplemented by scientific and reasonable calculation methods and evaluation strategies. By analyzing the problems, discussing the optimization method and demonstrating the calculation, it is proved that the model can effectively solve the above common problems.

Keywords: Graduation attributes attainment; Engineering educational reformation; TOPCARES; Meta-analysis; Non-technical index points

Publication date: October 2021; **Online publication:** October 26, 2021

1. Introduction

In this article, the problems need to be solved are extracted firstly, based on the analysis of evaluation of the graduation attributes attainment for 22 domestic and foreign universities. Secondly, the ideas and methods to solve the problems are explained separately on both global and local levels. An evaluation and analysis model of graduation attributes attainment on the basis of TOPCARES is proposed, based on the engineering education and teaching reform experience of Dalian Neusoft University of Information over the past 12 years. Then, the solutions to the four types of common problems are discussed in detail. Finally, the conclusion is given.

Graduate attributes (GA) refer to the knowledge, ability and quality objectives that students should achieve when they graduate, which should be able to support the achievement of professional training objectives. The “graduation requirement item” or “similar graduation requirement” mentioned in this paper has an inclusive relationship with the “graduation requirement index point,” that is, a “graduation requirement item” or “similar graduation requirement” contains multiple “graduation requirement index

points.”

2. Current situation and problem analysis

As China became the signatory of Washington Accord, inevitably colleges and universities in China had to face the problem of how to evaluate the quality of graduates. Among them, graduation attributes, as an important support for the achievement of cultivation objectives, have attracted more and more attention from stakeholders including universities, graduates, employers, and so on. The evaluation of graduation attributes attainment (also understood as graduation requirement achievement) is a critical approach to measuring the quality of professional cultivation in colleges and universities, which has a guiding role in the improvement of teaching activities. Through the evaluation results the evidence and references can also be provided for continuous improvement in various specialties^[1]. However, up to now, there is no accepted, mature and universal effective method to evaluate the graduation attributes. Dalian Neusoft University of information has been exploring the reform of engineering education for 12 years. The education methodology of TOPCARES has been put forward and practiced^[2]. Comprehensive cultivation and evaluation on students' disciplinary knowledge, professional skills and multiple qualities have been carried out. In particular, some beneficial exploration and practice have been made on the requirements of non-technical index points, the support of educational informatization and the scientificity of evaluation calculation methods.

2.1. Meta-analysis of evaluation

Meta-analysis^[3] is a method for analysis with the following characteristics: Meta-analysis is a quantitative analysis method, which is not the statistics of the raw data, but the re-statistics of the statistical results; Meta-analysis should include research with different quality; Meta-analysis seeks a comprehensive conclusion.

Using the method of Meta-analysis, a quantitative analysis has been made on the statistical data of the evaluation situation of graduation attributes attainment for 22 universities as samples, including 4 foreign universities^[4-5] such as the University of Ottawa, and 18 domestic universities^[6-8] distributed in Sichuan, Guangdong, Liaoning and Hunan. The following analysis process shows that the three characteristics of Meta-analysis are satisfied.

Let α represent the way of acquiring the evaluation results of non-technical index points. Specifically, α_1 represents acquiring indirectly (e.g. student survey by questionnaire, enterprise feedback information, etc.), α_2 represents acquiring directly (e.g. the evaluation of non-technical teaching objectives within the course, in extracurricular projects, in practice and other activities).

Let β stand for the subjectivity and objectivity of the weight setting between teaching objectives of different courses supporting the same graduation requirement index point. Specifically, β_1 stands for the subjective setting (e.g. from the discussion of the course teams), and β_2 stands for the objective setting (e.g. according to the calculation data of either the number of class hours in and after class, or the proportion of assessment scores, corresponding to the curriculum teaching objectives).

Let γ represent whether the “Wooden Barrel Short Board Principle” (e.g. using the lowest value as the final value) is used when counting the support state of each index point to its corresponding graduation requirement. Specifically, γ_1 means to use the lowest value as the final value for statistics, and γ_2 means not to use that theory for statistics (e.g. using three-dimensional evaluation, namely the overall attainment situation of that graduation requirement item is reflected by the three values together: the lowest value, the average / weighted average value and the highest value.)

Let δ stand for the degree of informatization support in each section of the evaluation of graduation requirements achievement degree. Specifically, δ_1 stands for deficient informatization support (e.g. mainly

based on manual information input, calculation, statistics and assessment), and δ_2 stands for sufficient informatization support (setting corresponding teaching and learning perception points in each teaching stage, and using information system as well as platform to input, calculate, count and evaluate the relevant information, etc.)

Table 1. Meta-analysis of the evaluation situation of graduation attributes attainment for domestic and foreign universities

Universities Investigated	Statistical Terms			
	Evaluation methods of Non-technical index points	Method of weight setting	Using the lowest value as final value or not	Deficient or sufficient informatization support
	α_1 / α_2	β_1 / β_2	γ_1 / γ_2	δ_1 / δ_2
Data distribution of 4 foreign universities	3 / 1	3 / 1	4 / 0	3 / 1
Data distribution of 18 domestic universities	15 / 3	16 / 2	17 / 1	13 / 5

2.2. Key problems to be solved

According to the statistical data by Meta-analysis listed in **Table 1.**, the key problems to be solved can be extracted as follows:

- Problem 1: Compared with the technical index points, the description of the non-technical graduation requirement index points is quite vague, and the measurability is generally weak, accounting for 81.8% of the 22 universities.
- Problem 2: The weight setting between different courses supporting the same index point is generally subjective, accounting for 86.4% of the 22 universities.
- Problem 3: The “Wooden Barrel Short Board Principle” is widely used, and the lowest value is always used as the final value for similar graduation requirement index points, which covers up the degree of achievement of other index points of similar graduation requirement, accounting for 95.5% of 22 universities.
- Problem 4: The deficiency of informatization support in evaluation sections leads to heavy workload, low efficiency and weak initiative of university teachers, accounting for 72.7% of 22 universities.

Figure 1, describes the position-points of the above key problems in the general process from index points design to attainment evaluation of graduation attributes.

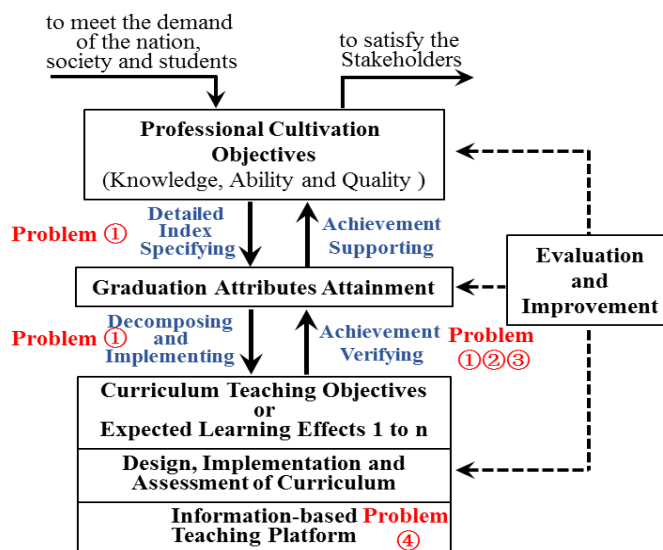


Figure 1. Position-points of key issues in GA attainment evaluation

Note that Problem 1, 2 and 3 have explicit correlation to the evaluation results of graduation attributes attainment, so they are in the position of “Achievement Verifying” in **Figure 1**. However, problem 1 is not only a problem of evaluation, but also about whether the design of index points is clear and evaluable. Therefore, it should also be in the positions of “Detailed Index Specifying” and “Decomposing and Implementing.”

3. Improved evaluation and analysis model based on TOPCARES

Since 2008, Dalian Neusoft University of Information has creatively put forward, constructed and implemented the integrated professional cultivation mode of TOPCARES, by learning from the achievements of international engineering education reform, also making it Chinese localization and with DUNI characteristics. TOPCARES represents an eight-ability-index system: **T**echnical Knowledge and Reasoning, **O**pen Thinking and Innovation, **P**ersonal and Professional Skills, **C**ommunication and Teamwork, **A**ttitude and Manner, **R**esponsibility, **E**thical Values, and **S**ocial Value Created by Application Practice. Its substantial content reflects the DNUI’s greatest care for students. Based on the educational concept of “Empower students with Innovative Education”, our university emphasizes that “the use of knowledge is more important than the possession of knowledge.” In addition to professional ability training, it also emphasizes the cultivation of students’ ideological and moral quality, innovation ability, personal professional ability, communication and expression and team cooperation ability.

Furthermore, the education with characteristics of DUNI also represents the ideas of creating the value of students by promoting the comprehensive and coordinated development of students’ knowledge, ability and quality, and creating the social value through students’ future contribution to the society, so as to realize the value of the university.

3.1. Optimization methods on basis of TOPCARES

The goal of the improved “evaluation and analysis model of graduation attributes attainment” is to make the evaluation results as close to the real situation as possible, that is, the difference between the results and the real situation is the smallest. The global and local optimization synthesis methods are used to minimize the impact of the key problems mentioned above on the evaluation results, thereby to achieve the optimization of the target.

Optimization methods on basis of TOPCARES include global optimization and local optimization, which are the methodological foundations of constructing the evaluation and analysis model of graduation attributes attainment. In the general process from design of index points to attainment evaluation of graduation attributes, aiming at the Problem 1 at the positions of “Detailed Index Specifying” and “Decomposing and Implementing,” and the Problem 4 at the position of “Course Evaluation,” the global optimization is adopted, i.e., the design, implementation, evaluation and informatization support (relying on Information-based Platform) of graduation requirement index points are carried out systematically and scientifically. For the Problem 1,2,3 at the position of “Achievement Verifying,” the local optimization is adopted, that is, the specific evaluation, calculation, analysis and methods of classification & application are optimized.

3.1.1. Global optimization

(1) Index system of TOPCARES

The TOPCARES index system is a framework guidance, including 8 first-level indexes, 34 second-level indexes and 126 third-level indexes, covering technical and non-technical index points, which is in line with the law of comprehensive and coordinated development of university students’ knowledge, ability and quality [2]. Specialized TOPCARES index system is the instantiation of the framework system of the

university, which is in line with the formation law of speciality cognitive model of the university students. **Table 2**, illustrates the TOPCARES index system for software engineering specialty in DNUI. The specialized description of third-level indexes are the corresponding index points of graduation requirements, which should be clear and evaluable.

Table 2. TOPCARES index system for software engineering specialty (partially showed)

TOPCARES (First-level indexes)	TOPCARES (Second-level indexes)	TOPCARES (Third-level indexes)	TOPCARES Specialized description on third-level indexes (Graduation requirement index points)	Technical index points T Non-technical index points N
	*
1 Technical knowledge and Reasoning	1.3 Basic professional knowledge	...	...	*
		1.3.2 Basic knowledge of software engineering	To master the basic knowledge of software engineering such as program design, data structure and algorithm, database principle and so on; be able to comprehensively use the above-mentioned knowledge to solve complex program development problems in software engineering and application fields	T
	*
...	*
4 Communication and Teamwork	4.3 Team work	...	...	*
		4.3.2 Team work operation	Be able to take on the role of individual, team member and leader in the team under the background of software engineering and related interdisciplinary, work according to the role requirements; be able to deliver work results on time with high quality	N
	5.1 Individual attitude and habit	5.1.2 Desire for knowledge and learning attitude	Have the desire to update knowledge and to promote self-improvement; constantly pursue progress in software engineering practice	N
5 Attitude and Manner	...	...	...	*
...	*
8 Social Value Created by Application Practice	...	...	...	*
	8.8 Implementation	...	...	*
		8.8.3 Developing software system to implement a solution	Be able to use software engineering methods, technologies and tools to develop software systems, components or models that meet the specific needs of software engineering and application fields according to the standardized software development process	T
	*

(2) The integrated professional cultivation mode of TOPCARES

On basis of TOPCARES, a series of quality standards and design implementation methods at different levels of specialty, curriculum and class ^[10], carry out the target decomposition, implementation and achievement support, from the professional cultivation objectives, graduation attributes to each teaching stage (such as curriculum, projects, activities, practical training etc.), respectively. More attention should also be paid to information-based “teaching and learning perception” and platform support simultaneously, i.e. setting corresponding teaching and learning perception points in each teaching stage, and using the information-based platform to input, calculate, count and evaluate the relevant information, etc.

3.1.2. Local optimization

According to the key problems with the position- points marked in Figure 1, the corresponding method optimization can be conducted:

- (1) For non-technical index points that are not easy to be evaluated, the synchronous evaluation mode of combining direct and indirect evaluation can be carried out. For example, using but not limited to “performance analysis method based on the evaluation of the achievement of curriculum objectives or expected learning effects” (a direct evaluation method) and “questionnaire method for fresh graduates” (an indirect evaluation method) are the two main evaluation methods.
- (2) The weight of different curriculum teaching objectives supporting the same graduation requirement index point can be calculated scientifically and reasonably by using quantitative calculation method, that is, according to the data of class hours in and after class or the proportion of assessment scores, corresponding to the curriculum teaching objectives.
- (3) In order to avoid the occurrence that some valuable information of other index points is covered up due to the selection of the lowest value strategy, it would be better to use a three-dimensional evaluation and classification application method, namely the overall attainment situation of that graduation requirement item is reflected by the three values together: the lowest value, the weighted average value and the highest value. In addition, the corresponding values are selected according to different application needs.

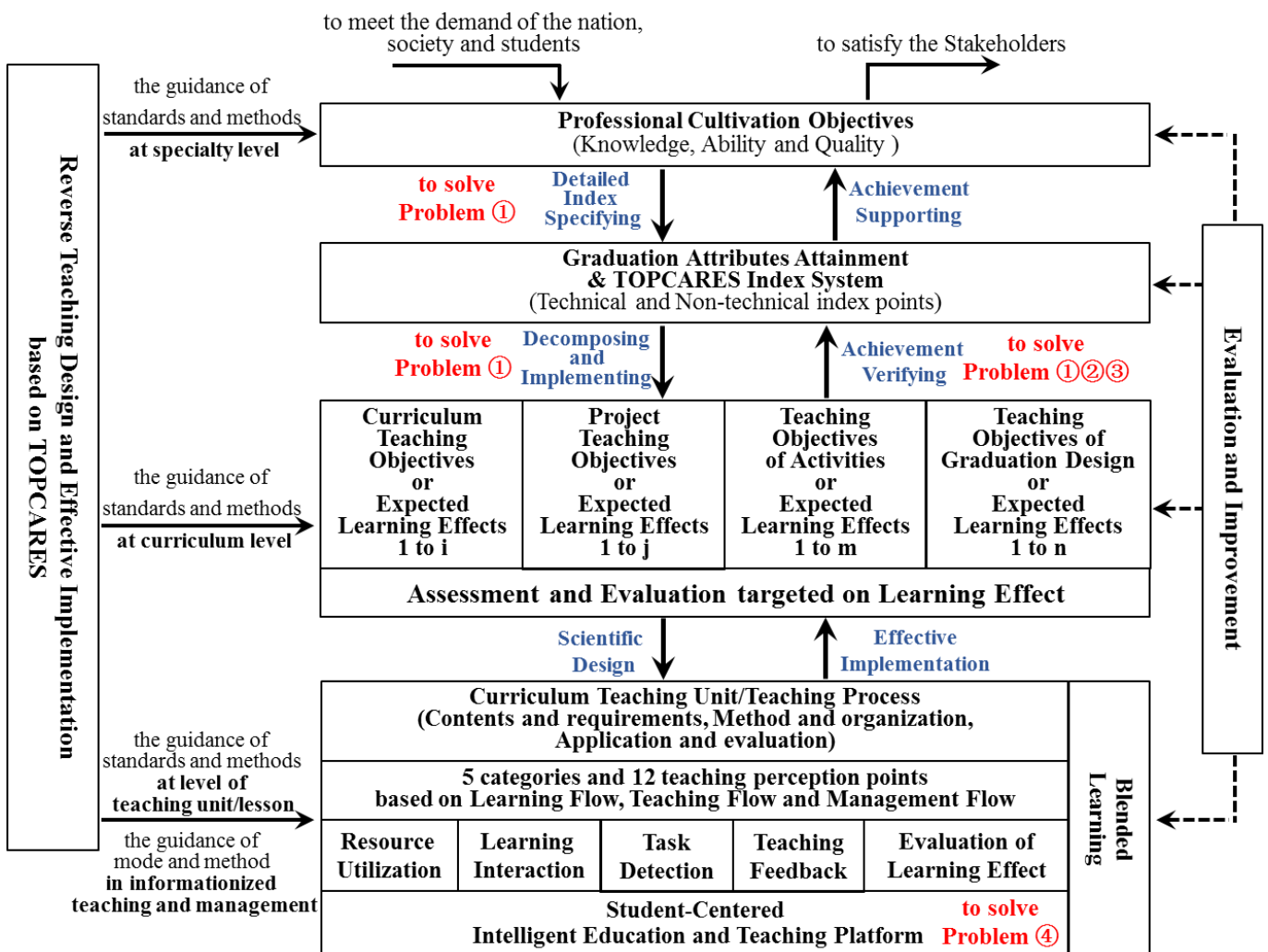


Figure 2. Evaluation and analysis model of graduation attributes attainment based on TOPCARES

3.2. Improved evaluation and analysis model of graduation attributes attainment

Professional cultivation objectives and graduation attributes should be decomposed into each teaching step such as courses, projects and activities etc. Furthermore, the latter should also provide measurable, scientific and reasonable support for the former.

Figure 2 shows the evaluation and analysis model of graduation attributes attainment based on TOPCARES optimization method, which describes the guidance of TOPCARES standards and methods at different levels of specialty, curriculum and teaching unit / lesson. In addition, the specific position-points to solve the above mentioned four key issues are also marked in **Figure 2**.

The TOPCARES index system (as shown in **Table 2.**), the decomposition, implementation and evaluation of those indexes in courses, projects and activities, as well as the standards, methods and modes at the levels of specialty and curriculum, provide sufficient assurance for the quality of professional cultivation [9]. Meanwhile, the design, collection and analysis of perception points based on learning flow, teaching flow and management flow, together with the use of student-centered intelligent education and teaching platform, have effectively improved the timeliness, effectiveness and scientificity of perception and evaluation of knowledge, ability and quality achievement in the process of professional cultivation. In a word, by comprehensively using the global and local optimization, the influence of the above mentioned key problems on each position-point is minimized as far as possible, thereby to achieve the optimal overall target value.

4. The optimal solution of common problems by TOPCARES practice

4.1. To solve the problem of non-technical index-points

The achievement of non-technical index point is an indispensable component of the professional cultivation system. For the non-technical index points that are not easy to be evaluated, direct evaluation can be conducted through clearly setting the corresponding in-class teaching objectives and extracurricular projects, practice and other activities, supplemented by indirect evaluation such as questionnaires etc.

The levels of activities include university-level, school-level and department-level; the categories include disciplines competition, scientific research project, innovation & entrepreneurship project and quality education, etc. By investigating the self-evaluation report and other supporting materials, the evaluation is carried out on basis of the "Evaluation Standard of Activities". The evaluation modes include but are not limited to document inspection, defense, on-site investigation, questionnaire survey, etc. Finally, the evaluation conclusion and improvement suggestions are gathered and fed back.

The total score of the evaluation result is calculated according to the weighted index grade, and each index grade includes A (1.0) / B (0.8) / C (0.6) / D (0.4). The final evaluation conclusion is divided into four levels: Excellent [100-90], Good (90-80), Qualified (80-70), and Unqualified (less than 70 points).

4.2. To solve the problem of the subjectivity of weight setting

Let Hour (I) represent the number of class hours which is needed to support the i-th teaching objective or the expected learning effect of the course.

Therefore, Hour (I) = the required class hours + the equivalent class hours after class. Here Hour (I) is abbreviated as H_i .

The proportion of the importance of the i-th expected learning effect of the course is Ratio (I), abbreviated as R_i .

In addition, considering the importance of this course itself in the cultivation system, taking a 64-class-hour course as the reference, an equation can be obtained:

$$R_i = \frac{H_i}{\sum_i H_i} \times \frac{\sum_i H_i}{64} = \frac{H_i}{64} \quad (1)$$

Achievement degree is represented using $\Phi = \{\phi O, \phi T, \phi G\}$; where ϕO is the abbreviation of ϕ Outcome, which means the achievement degree of expected effect; ϕT is the abbreviation of ϕ Topcares, which means the achievement degree of TOPCARES index (e.g. graduation requirement index point); ϕG is the abbreviation of ϕ Graduate, which means the achievement degree of graduation requirement item.

Given a TOPCARES third-level index $T_{x, y, z}$ (corresponding to the s -th index point of the r -th graduation requirement, $T_{r, s}$) is supported by three courses respectively, i.e. the i -th index of the first course O_i , the j -th index of the second course O_j , and the k -th index of the third course O_k , their corresponding importance proportions are R_i, R_j , and R_k , and their corresponding achievement degrees are $\phi O_i, \phi O_j$ and O_k , then the achievement degree corresponding to $T_{x, y, z}$ (i.e. $T_{r, s}$) can be represented as follows:

$$\phi T_{r, s} = \phi T_{x, y, z} \tag{2}$$

$$\phi T_{r, s} = \omega 1 \times \phi O_i + \omega 2 \times \phi O_j + \omega 3 \times \phi O_k \tag{3}$$

In Equation (3):

$$\omega 1 = \frac{R_i}{R_i + R_j + R_k} = \frac{H_i}{H_i + H_j + H_k} \tag{4}$$

$$\omega 2 = \frac{R_j}{R_i + R_j + R_k} = \frac{H_j}{H_i + H_j + H_k} \tag{5}$$

$$\omega 3 = \frac{R_k}{R_i + R_j + R_k} = \frac{H_k}{H_i + H_j + H_k} \tag{6}$$

According to the above-mentioned equations and calculation methods, the weight setting becomes more scientific and objective.

4.3. To solve the irrationality by adopting the “Wooden Barrel Short Board Principle”

It is more reasonable to use a three-dimensional evaluation, e.g. the overall attainment situation of a certain graduation requirement item is reflected by the three values together: the lowest value, the average / weighted average value and the highest value. For example, if the r -th graduation requirement item contains four index points, and its achievement degree can be shown in **Table 3**.

Table 3. An example of three-dimensional evaluation of a certain graduation requirement item

$\phi T_{r,1}$	$\phi T_{r,2}$	$\phi T_{r,3}$	$\phi T_{r,4}$	the lowest value ϕG_r	the average value ϕG_r	the highest value ϕG_r
0.756	0.834	0.623	0.901	0.623	0.779	0.901

The loss of useful information can be avoided by adopting the three-dimensional evaluation. Object oriented can be individual students or group students. When analysing and applying the results, they can be classified as follows:

- (1) the lowest value of ϕG is used for the basic standard evaluation.
- (2) the average value of ϕG is used for the comprehensive evaluation.
- (3) the lowest or the highest value of ϕG can be selected according to the specific situation when conducting the personalized screening evaluation.

4.4. To solve the problem concerning informatization support

The informatization support has been strengthened in all aspects of graduation attributes attainment in

DNUI. The “Calculation and Analysis System for Graduation Attributes Attainment” for various specialties has been developed according to the DNUI’s official regulation document of “Evaluation Methods of Professional Graduation Attributes Attainment,” thereby the improvement of teaching quality in each academic year can be realized. A certain “integrated blended learning and evaluation system” has been developed at the curriculum level, realizing the phased improvement and final improvement of each semester.

Moreover, the application of big data in teaching action has also been enhanced. According to the general essentials of effective teaching design and implementation (e.g. objectives, teaching methods, learning methods, and evaluation) ^[10-11], and the “Learning effect” oriented educational idea, five types of teaching perception points are set as: effective utilization of resources, degree of interaction and participation, timeliness of task completion, feedback effect of teaching, and achievement of learning objectives. Therefore, the quality evaluation and monitoring based on teaching perception have been realized. These measures make the quality monitoring more independent, problems detecting more timely, teaching improvement more reachable, and the evaluation of students’ learning process and results more scientific, more efficient and more accurate, while reducing the teachers’ workload.

5. Conclusion

The main task of colleges and universities is professional cultivation. How to measure the quality of professional cultivation, that is, how to measure the degree of achievement of knowledge, ability, quality and other graduation requirements has become the key point. In this paper, a meta-analysis on the mode, method and evaluation process of the graduation attributes attainment for 22 domestic and foreign universities has been made firstly, and four common problems have been listed then, namely, the evaluation of non-technical index points, the weight setting among the courses supporting the index points of graduation requirements, the information loss of setting the final value by using the “Wooden Barrel Short Board Principle,” and the insufficient utilization of information means. Based on the 12 years’ experience of engineering education and teaching reform in Dalian Neusoft University of Information, this paper gives the ideas and methods to solve the problems on both global and local levels, and puts forward the evaluation and analysis model of graduation requirements achievement degree based on TOPCARES, supplemented by scientific and effective calculation methods and evaluation strategies. Through problem analysis, optimization method discussion and demonstrative calculation, it is proved that the model can solve the above-mentioned common problems effectively.

In the future, the iterative optimization of the evaluation method based on teaching big data will be focused on, to improve the scientificity and accuracy of the evaluation of graduation requirements, and further reference cases can be provided for similar research.

Funding

Liaoning Province Education Science Approved Project within “the 13th Five-Year Plan”: “A Study on the Outcome-based Evaluation Model of Practical Courses” (Project Approval No. JG18DB031).

Disclosure statement

The author declares no conflict of interest

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