Teaching Reform and Continuous Improvement of the Course "Electrical Machinery" under the Background of New Engineering

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Abstract. In view of the problems existing in the teaching of the course "Electrical Machinery" under the background of new engineering, the knowledge system of the course has been optimized and constructed, and the course objectives have decomposed and refined layer-by-layer. A three-dimensional closed-loop teaching mode and a diversified assessment and evaluation system are designed, Ideological and political course runs through the whole process of teaching, and the results show that the reform strategy has a good effect on improving the overall quality of the course, However, there are still some problems in curriculum team ability, curriculum system, teaching resources, ideological and political integration, teaching mode and assessment content. Adhere to the concept of continuous improvement, and put forward the direction and measures for improvement.

Keywords: curriculum system; combination of theory and practice; teaching mode; assessment method; continuous improvement

1 Introduction

The construction of new courses is one of the important measures to lead the "quality revolution" of higher education in China [1]. At present, China's power industry is facing the deep integration of new energy, information, artificial intelligence, cloud computing, etc., and it is developing in the direction of intelligence, cleanliness and sustainability [2],[3], such as high proportion of renewable energy access, smart grid, energy storage technology and digital transformation. The transformation and upgrading of traditional electrical engineering majors, adhering to student-centered and results oriented approaches[4], constructing a new curriculum system with a new engineering background[5], reforming curriculum teaching modes[6], improving overall quality of courses, and enhancing curriculum quality, in order to cultivate high-quality composite talents with strong practical and creative abilities, is the only way to meet the talent demand of technological progress and rapid social development. Curriculum is the core of personnel training and the key to achieve the goal of personnel training [7], the course "Electrical Machinery" is to support the goal of training talents of electrical engineering and automation specialty in our university (Based on Guizhou and facing the central and western regions, in order to adapt to the development of socio-economic development, cultivate the comprehensive development of morality, intellectual, physical and

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labor, have a sense of social responsibility, professional ethics, humanities and innovative spirit, with solid professional basic knowledge and a certain international perspective, applied engineering and technical personnel who can be engaged in management, operation and maintenance, technical transformation and service in the fields of power system and electrical equipment), as well as engineering knowledge, design/development solutions and other graduation requirements of a comprehensive professional core basic course [8], it plays a key role in the curriculum system, it is the basis of subsequent professional courses such as power system analysis, electrical equipment of power plants and substations, and relay protection of power system.

In order to improve the quality of electrical machinery course, based on the survey data, the teaching reform of the course is carried out from the aspects of teaching objectives and content system, teaching mode, assessment and practice, it also summarizes the effectiveness of the reform and the existing problems, which provides a basis for the continuous improvement of the curriculum.

2 Analysis of curriculum problems

"Electrical Machinery" is the core course of the quality of personnel training in electrical engineering specialty, and has a prominent and important position in the curriculum system. The course has the characteristics of wide knowledge coverage, strong theory, abstract concept and close connection with engineering practice. It is necessary to use the basic knowledge of mathematics, circuit, electromagnetic field, machinery and other disciplines to construct the theoretical model of motor and analyze its working principle and characteristics, the theoretical knowledge of electrical machinery has used to analyze and study the complex engineering problems related to the manufacture and operation of electrical machinery, to lay a solid theoretical foundation for the follow-up study of professional courses. After investigation, there are the following problems in the syllabus, content, teaching mode and assessment of this course in 2018 Class and 2019 Class.

2.1 "Knowledge, ability and value" fail to improve synchronously

In 2019 class and before, the total class hours of the course are 48 theory class hours, and the fourth semester is offered. There are six parts of learning content (total chapter 12), that is basic theory, transformer, AC motor, three-phase asynchronous motor, three-phase Synchronous Motor and DC motor, the class hours is respectively 2 hours, 10 hours, 4 hours, 14 hours, 10 hours and 8 hours. Due to the limitation of class hours, the combination of selecting key knowledge explanation and students self-study is adopted to carry out teaching, although this method can increase the coverage of the course content, students self-study enthusiasm and self-study ability are relatively lacking, and they cannot complete the self-study content well, resulting in incomplete and unsystematic mastery of the course knowledge. Because of the rapid progress of teaching, the key knowledge taught is not thorough, so it can only "sneak in and out", moreover, students self-study content understands and does not have in place, and there is a contradiction between the coverage and depth of the course content, the phenomenon of "seemingly understanding but not understanding" is widespread, especially the basic concepts and principles, which not only affects the interest and enthusiasm of

learning, and can't better achieve the improvement of knowledge and ability. It hasn't fully tapped the ideological value and spiritual content contained in the knowledge system, and has been organically integrated into the curriculum teaching, the value hasn't been improved synchronously.

2.2 Theory and practice aren't closely connected

The course does not combine its theoretical and engineering application characteristics to set up practical courses or projects, such as experiments, program design, virtual simulation, etc, only through theoretical explanation and analysis, can't establish a good link between theory and practical application, although some animation and video assistant teaching related to engineering practice are introduced in the course, the effect is not obvious, there is insufficient support for cultivating students engineering thinking mode, innovation ability, practical ability and ability to solve practical engineering problems under the background of new engineering.

2.3 Single assessment method, unable to evaluate the teaching effect scientifically and objectively

The course assessment consists of process assessment for 30% and final examination for 70%.The process assessment is mainly based on attendance, homework and classroom performance, and there is no detailed scoring system or standard for each assessment item, so the scoring is not constrained and subjective. The process assessment of proportion is low and the assessment is not diverse enough, which can not comprehensively evaluate the learning process and learning effect, the assessment is not scientific, it can not stimulate students interest in learning, mobilize their enthusiasm, initiative and participation. The proportion of final examination is high, subjective questions only account for about 40%, closed-book way, and students are highly dependent on memory and examination-taking ability, "Assault clearance" appears to be widespread, which can not comprehensively assess students potential and comprehensive ability.it is not conducive to the cultivation of students comprehensive quality and innovative ability.

3 Teaching reform strategies

In view of the problems existing in the teaching of course "Electrical Machinery" in our school, with the goal of autonomous learning ability, knowledge application ability, practical innovation ability and value shaping, and in order to meet the needs of talent training of electrical engineering specialty under the background of new engineering, the reform studies have been carried out, including the construction of modular teaching system, the design of experimental project combining theory with practice, the exploration of teaching mode and the design of diversified assessment and evaluation system.

3.1 Construction of modular teaching system

It is guided by the idea of new engineering construction and guided by the goal of supporting professional personnel training and graduation requirements, combining with the characteristics of the curriculum, the orientation of the school and the demand for talents in the industry, this paper should further clarify the teaching objectives and break through the

chapter stereotype, the teaching content is optimized and the modular teaching system is constructed.

1. The three-dimensional integrated goal of curriculum knowledge, ability and value are optimized and established. It also supports the three graduation requirements of "Engineering Knowledge, Design/Development Solutions and Research". Objective I: understand and master the basic structure, principle and analysis method of transformer, asynchronous motor, synchronous motor and DC motor, master the method and idea of establishing the theoretical model of transformer and motor. Objective II: students be able to establish the mathematical model of motor theory and calculate its relevant performance parameters, and able to analyze, optimize and check the performance of the motor according to the parameters. Objective III: students have the ability to use theoretical knowledge to conduct preliminary analysis and research on the problems in the process of motor manufacturing and operation, to cultivate self-study ability, dialectical thinking ability and innovative spirit, rigorous and meticulous work style and professional quality.
2. The course class hours are optimized from 48 to 64, and the course content is modularized according to the relevant knowledge points, which are combined into six modules according to basic theory, transformer, common problems of AC motor, asynchronous motor, synchronous motor and DC motor. It also clarifies the key and difficult points of each module and follows the principle of "from simplicity to complexity, first concept and principle, then analysis and application", and teaching in the order of structure, physical model, mathematical model, character is tics, application [9]. In the process, it organically integrates ideological and political education and expands the frontier technology of disciplines, enriches the teaching content, and strengthens the value shaping of students. The constructed course knowledge system is shown in Table 1, in which "*" is the supplementary and complete content.

Table 1. Course knowledge system

Course modules	Class hour optimization	Main content
Basic theory	Adjusting 2 to 4	a. Classification of motors. b. Magnetic circuit and magnetic circuit law. c. Basic theory of electromagnetism. d. *Motor manufacturing materials.
Transformer	Adjusting 10 to 14	a. Classification, construction and rating. b. Basic principles and operating characteristics (no-load, on-load and parallel). c. *Transformer reduction, equivalent circuit, phasor diagram and parameter determination. d. Magnetic circuit and connection group of three-phase transformer. e. Excitation current, magnetic flux and per unit value in transformer. f. *Voltage change rate and efficiency of transformer. g. *Special transformer.

AC motor	Adjusting 4 to 12	a. Function and principle of rotating motor. b. Three-phase single-layer and double-layer windings. c. Conductor electromotive force star diagram and fundamental electromotive force. d. Coil fundamental EMF and pitch factor. e. *Pulsating magneto motive force of single-phase winding and its decomposition. f. Three-phase winding is combined into magneto motive force. g. *Heating, temperature rise and cooling of motor.
Three-phase Asynchronous motor	Adjusting 14 to 14	a. Structure, operation state and magnetic field of asynchronous motor. a. Operating characteristics, starting current and starting torque of asynchronous motor. b. *Operation characteristics, power equation and torque equation of the asynchronous motor. c. Starting and speed regulation of squirrel cage and wound-rotor induction motors. d. Operation of three-phase asynchronous motors under asymmetric voltage, single-phase asynchronous motors
Three-phase Synchronous Motor	Adjusting 10 to 12	a. Construction, characteristics and parallel operation of synchronous machines. b. *Analysis method of non-salient pole and salient pole synchronous machines. c. Power-angle characteristics of non-salient pole and salient pole synchronous machines.
DC motor	Adjusting 8 to 8	a. DC motor structure, basic principle and electromagnetic relationship. b. *The induced EMF, voltage and balance equation of the armature winding. c. DC motor's direction and method

3. To sort out the key and difficult points teaching in each module and chapter of the course, the course objectives are broken down layer by layer according to course, course module, chapter, knowledge point, and combining with the characteristics of teaching content, we should establish ideological and political objectives, excavate ideological and political elements, match ideological and political cases, exert a subtle influence and moisten things silently, and organically combines the understanding, mastery and comprehensive application of knowledge with the promotion of value, so as to realize the integration of knowledge imparting, ability training and value shaping.

3.2 Combination of theory and practice, highlighting ability training

Following the knowledge logic of each module of electrical machinery course and the cognitive law of students, in order to further improve students understanding and mastery of the structure and working principle of various types of electrical machinery, and highlight the cultivation of students AP plication ability, the comprehensibility of knowledge points with strong abstraction is improved by means of pictures, animations, videos and experiments in the course, strengthen the cultivation of students ability to apply knowledge to analyze and solve problems and their ability to practice and innovate. For example, use pictures to show the application of various motors and transformers in engineering practice, use three-dimensional animation or disassembly video to learn the structure and working principle of

various motors and transformers, use experiments to strengthen the operation characteristics, mechanical characteristics and control of various motors. Based on the course knowledge system and course objectives, 26 experimental projects are designed around the four modules of transformer, asynchronous motor, synchronous motor and DC motor, as shown in Table 2. Each round of teaching combines the weak links of theoretical learning, and 2 to 4 hours of experiments are offered after the end of the theory.

Table 2. Experimental items of each course module

Course modules	Experimental project
DC Motors	a. DC, excitation, and compound motivation of the operating characteristics experiment b. Experiments on operating characteristics and mechanical characteristics of electrical machines c. Experiment on Speed Regulation Characteristics of Motor d. DC His motor motor electric and feedback braking feature experiments e. DC The Electric Electrical Electrical and Reverse Brake Features Experimental Experiment f. Experimental Study on Energy Dissipation Braking Characteristics of Separately Excited DC Motor
Transformer	a. No-load, short-circuit and load test of single-phase transformer b. Ratio Measurement and No-load Characteristic Test of Three-phase Transformer c. Experiment on Short-circuit Characteristics and Load Operation Characteristics of Three-phase Transformer d. Experiment on Polarity and Connection Group Discrimination of Three-phase Transformer e. Single-phase short circuit test of Y/Y0 connection of three-phase transformer f. Two-phase Short Circuit Test of Y/Y Connection of Three-phase Transformer
three-phase Asynchronous motors	a. Mouse cage motor load method work characteristics and parameter measurement experiment b. Start and Speed Regulation Experiment of Wound-rotor Motor c. Experiment on working characteristics of two-speed motor d. Experimental study on braking characteristics of wound-rotor motor e. Experiment on Motor-Driven and Reverse Braking Characteristics of Wound-Rotor Motor f. M-S Curve Mapping Experiment of Squirrel-cage Motor and Wound-rotor Motor g. Experiment on Inching and Self-locking Control of Squirrel-cage Motor h. Experiment of Positive and Negative Rotation Control for Interlocking of Squirrel-cage Motor Contactor i. Y/△ Step-down Starting Control of Squirrel-cage Motor
three-phase synchronous motors	a. Operation characteristic experiment of the motor under symmetrical load b. Parallel Operation Experiment of Motor c. Experiment on V-shaped Curve and Working Characteristics of Electric Machine

3.3 Teaching mode reform

Teaching methods and means are the key to ensure the quality of teaching. In view of the problems existing in theoretical teaching, such as difficulty in mobilizing interest and enthusiasm in learning, incomplete understanding of knowledge points, unclear thinking of

problem analysis, and lack of obvious improvement in problem-solving ability and value shaping, the three- dimensional closed-loop teaching mode are designed with offline as the main part, online as the auxiliary part, integration of various teaching methods and means[10], the whole process before, during and after class is integrated into ideological and political teaching, as shown in Fig.1. Pre-class tasks concretize learning objectives and existing problems, internalize theoretical knowledge into practice through in-depth explanation, imitation and experiment of theoretical knowledge in class, and consolidate theoretical knowledge by completing testing, homework, expanding reading, reflection and summary after class to enhance comprehensive application ability and literacy. To realize the synchronous promotion of knowledge imparting, ability training and value shaping.

3.4 Construction of Diversified Assessment and Evaluation System

A scientific and comprehensive assessment system is an important means to test the teaching effect. In view of the problems existing in the previous course assessment, it should reduce the proportion of final assessment, strengthen the process assessment, set up diversified assessment items and evaluation criteria, so as to realize the integrated multi-dimensional assessment and evaluation of students' knowledge, ability and value. The course achievement can be calculated by the following formula (1).

$$ACH=\sum_{i=1}^{m}\frac{X_i}{100}\times a_i+\frac{T_e}{100}\times a_{ET}+(\sum_{j=1}^{n}\frac{Y_j}{Z_j}\times b_j)\times a_{PE} \tag{1}$$

where, ACH is the achievement degree of the overall objective of the course. X_i and a_i are respectively the average score of the i^{th} process assessment method and its proportion in the comprehensive score. T_e and a_{ET} are respectively the average score of the experimental examination and the proportion in the comprehensive score. Y_j and Z_j are respectively the average score and full score of the j^{th} module in the final assessment. a_{PE} and b_j are respectively the proportion of the final assessment in the comprehensive score and the proportion of the class hours of the j^{th} module.

Process assessment still accounts for 30%. In order to highlight the cultivation of students' learning ability and ability to analyze and solve problems, the proportion of attendance, discussion and chapter testing should be reduced, and the proportion of homework and online learning should be increased, that is respectively from 3% to 1.5%, 6% to 4.5%, 9% to 1.5%, 9% to 18%, 3% to 4.5%, and continue to optimize the discussion, testing and operation contents in accordance with the principle of "reducing the order and increasing the order". Increase the experimental assessment by 10% to highlight the ability to analyze problems, solve problems and practice innovation ability. The proportion of final assessment is optimized from 70%to 60%, scenario design, openness, inquiry and comprehensive topics related to engineering practice are added to the test questions to high- light the comprehensive application ability of assessment.

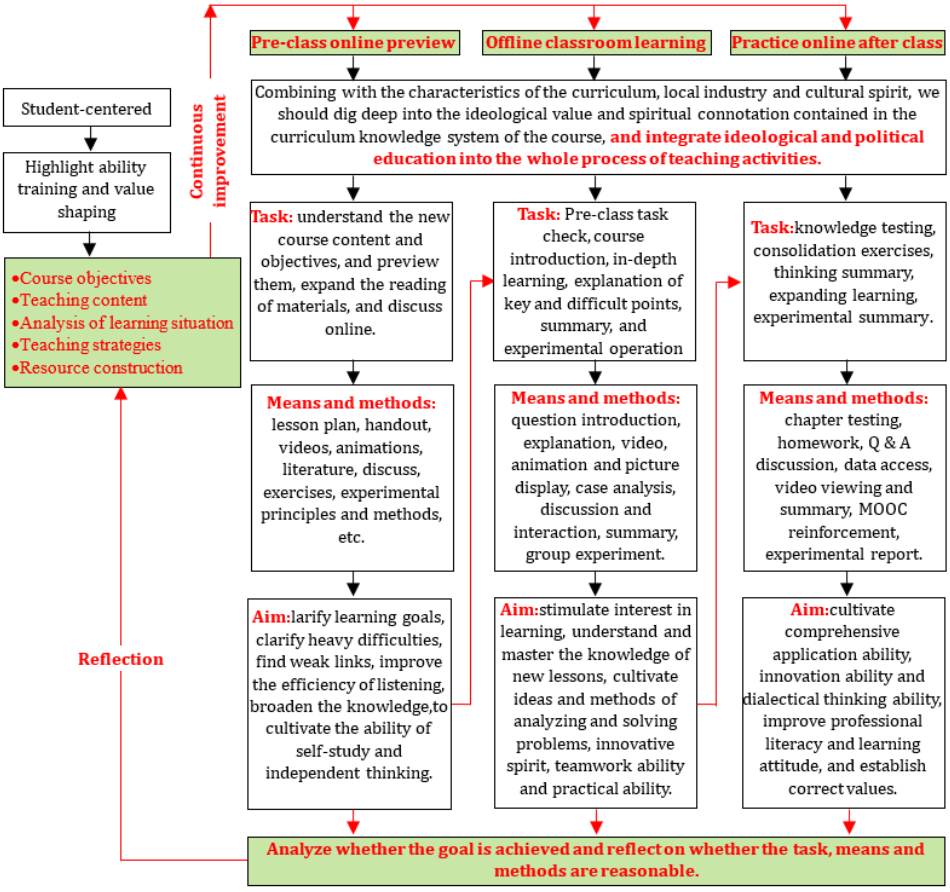

Figure 1.Design of three-dimensional closed-loop teaching mode

4 Reform effectiveness and continuous improvement

4.1 Analysis of reform effect

The course objectives are broken down layer by layer according to course, course module, chapter, knowledge point, it can provide more specific guidance and direction for teaching and learning, and design and organize teaching pertinently, which has a good effect on improving teaching effect and learning level. For example, the knowledge objectives of the basic theory module can be decomposed into: knowing the magnetic circuit and the relevant laws of the magnetic circuit, compare and analyze with the circuit and the relevant laws of the circuit, and understand the principle of energy conservation. The ability to calculate the relevant laws of the magnetic circuit according to the relevant laws of the circuit, and to carry out simple calculation and analysis of the magnetic circuit. Accord to that principle of energy conservation in the process of energy transmission, to train students to integrate the awareness of energy saving, environmental protection and safety into engineering calculation. The

curriculum reform strategy is organized and implemented in 2020 class and 2021 class, and the distribution and achievement of the assessment results are shown in Table 3 and Table 4. From Table 3 and Table 4 shows the results follows:

Table 3. Distribution of scores before and after curriculum reform

Grade	Comprehensive score			Synchronous motor module Score	
	2019 Class	2020 Class	2021 Class	2019 Class	2020 Class
Excellent(%)	0	0	0	0	8.2
Good(%)	5.4	16.3	12.8	3.6	8.2
Medium(%)	23.2	18.4	51.1	12.5	10.2
Pass(%)	44.6	42.9	34	14.3	20.4
Fail(%)	26.8	22.5	2.1	69.6	53.1

Table 4.Achievement of each assessment method

Assessment method		Comprehensive			Synchronous motor module	
		2019 Class	2020 Class	2021 Class	2019 Class	2020 Class
Process	Attendance	0.833	0.981	0.976	-	-
	Discussion	0.89	0.956	0.789	-	-
	Detect	0.895	0.837	0.771	-	-
	Online	0.879	1	0.960	-	-
	Homework	0.882	0.846	0.851	-	-
	Overall	0.882	0.892	0.86	-	-
experiment		-	0.835	0.854	-	0.835
Final Examination		0.55	0.487	0.585	0.459	0.554
Comprehensive		0.65	0.643	0.694	-	-

Note: No experiments were carried out on the 2019 class synchronous motor module

1. The reform strategy has a good effect on improving the overall quality of the course. Among them, the excellent rate and passing rate of 2020 class were only 10.9% and 4.3% higher than those of 2019 class, and the effect of the reform was not obvious. The main reason is that the reform measures of curriculum team are not yet perfect, and there are deviations in the implementation, students have not yet fully adapted to the new teaching mode and assessment scheme. After a teaching cycle, the team reflects on and summarizes the problems existing in the reform, and follows the principle of continuous improvement, continuously optimize the teaching content and assessment scheme, strengthen the construction of curriculum resources, improve the experiment, and integrate ideological and political education into the teaching. The average score of 2021 class accounted for more than 50%, and the excellent rate and passing rate increased by 7.4% and 24.7% compared with 2019 class, with obvious effect.
2. The achievement degree of the process assessment of each grade is greater than 0.8, which indicates that the students have a good grasp of the knowledge of memory and understanding. Among them, attendance and online learning have been improved compared with before the reform. It shows that the reform is effective for students to change their learning attitude and improve their learning enthusiasm and initiative. The achievement of discussion, detection and operation in 2021 is lower than that in 2019 and 2020.It reflects that students'thinking and ability of application, analysis and innovation need to be improved. The

principle of "reducing the lower level and increasing the higher level" to adjust the assessment content is feasible.

3. The result of the compared with theoretical knowledge learning, students are more interested in experiments, and the effect of understanding and mastering knowledge through experiments is better. The excellent rate, passing rate and achievement degree of the 2020 synchronous motor module are 12.8%, 16.5% and 20.7% higher than those of the 2019 class synchronous motor module. This also shows that the effect of interspersing experiments in the course is obvious.

4. There are still some challenges and difficulties for students to increase the open, exploratory and comprehensive test questions related to engineering practice. The achievement degree of the final assessment of Grade 2020 and 2021 class is less than 0.6. It shows that the ability of students to analyze and solve practical engineering problems with comprehensive application of knowledge needs to be improved. The achievement degree of the final assessment of 2021 class is 20.12% higher than that of 2020 class. It reflects that it is necessary to increase the training of high-level topics in the process assessment stage. This also points out the direction for the later continuous improvement of the teaching mode and the examination and process assessment strategy.

4.2 Continuous improvement

Although the curriculum reform has achieved certain results, it also reflects some shortcomings that require in-depth exploration and reform based on the concept of continuous improvement [11]. The specific measures are as follows.

1. Strengthen the construction of curriculum team, participate in online or offline training through sharing and discussion, and broaden the scope of knowledge. Updating the knowledge system and improving the teaching ability and level.

2. Perfecting the course system and experiment, the contents of various types of motors are deeply optimized according to the steps of structure, physical model, mathematical model, characteristics and application, Form a mind map and a learning guide outline, and increase the hours of the experimental part. Physical experiments or virtual simulation experiments are combined with theoretical teaching in transformer, DC motor, asynchronous motor and synchronous motor, In order to strengthen the understanding and mastery of theoretical knowledge, a certain number of hours of experiments are offered in the four modules of the computer, enhance the comprehensive application ability and practical innovation ability.

3. The construction of resources is not rich enough, and we should make full use of the online teaching platform of "Micro Assistant H5, Learning Link". Modular, hierarchical and path-oriented construction is not limited to online preview tasks, expanded reading and themes in the form of text, video and animation. Discussion, chapter testing, homework after class, ideological and political cases and other resources, in order to improve the support of preview before class and intensive exercises after class.

4. In-depth study of course content, combined with industry, continuous optimization and excavation of ideological and political content. Improve the relevance between ideological and political elements and curriculum knowledge content, and insist on multi-channel integration in the whole process of teaching, In order to improve the quality of curriculum value shaping, the proportion of high-level thinking ability training topics should be increased in the process assessment. Strengthen the training of knowledge application ability and innovation ability.

5. Continue to adopt the assessment design of "process, experiment and final", and continuously optimize the assessment items, proportion and content. Process assessment accounts for 35%. The attendance, discussion, subject interaction and online learning in the original scheme are integrated into classroom performance assessment, accounting for 10%. The proportion of homework and chapter testing (including a mid-term test) is optimized to 10% and 10% respectively. It also adds some high-level assessment contents and increases the assessment of ideological and political practice, accounting for 5%. Further stimulate students'learning enthusiasm and initiative, and strengthen ability training and value shaping. The experimental assessment accounted for 15%, and the assessment was carried out from the two dimensions of experimental operation and experimental report, accounting for 5% and 10% respectively. Highlighting the cultivation of students' ability of problem analysis and practical innovation. The proportion of final assessment is optimized to 50%, so as to strengthen the process assessment and continuously optimize the assessment questions that highlight ability training and value shaping.

5 Conclusion

It adheres to the concept of "student-centered, output- oriented and continuous improvement"[12]. It is the key to improve the teaching quality to highlight the "gender equality" and the teaching reform and innovation. It highlights the cultivation and value shaping of students'learning ability, problem analysis and solving ability, practical and innovative ability. In order to meet the needs of social development for applied talents of electrical engineering under the background of new engineering. To this end, the curriculum team has optimized and constructed a 64-hour knowledge system of curriculum teaching content. The course objectives are decomposed layer by layer according to course, course module, chapter, knowledge point. The three-dimensional closed-loop teaching mode of "goal-task-mode-evaluation-adjustment" is designed before, during and after class. It explores the teaching of offline, online assistance, combination of theory and practice, integration and application of various teaching methods and diversified assessment and evaluation of the whole process.

The implementation path, practice shows that the reform strategy can promote the effective achievement of the trinity goal of "knowledge imparting, ability training and value shaping". Analyze that gap between the achieved effect and the preset goal, it puts forward the direction of continuous improvement of curriculum team ability, curriculum system, teaching resources, ideological and political integration, teaching mode and assessment system. Measures are taken to make the teaching of electrical machinery in a state of continuous improvement.

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