The Five-in-one Systematic Reform of the Mechanical Foundation Series

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***Abstract*—From the perspective of the overall and system, the teaching contents of the five courses of Engineering Graphics, Mechanical Design Foundation, Mechanical Manufacturing Foundation, Interchangeability and Technical Measurement, and Engineering Mechanics are expanded into five modules, to build a "five in one" curriculum system. Through reconstructing the teaching contents of the five modules, the overall planning of the teaching case, and taking the design of reducer as a scenario clue, the teaching contents of the scattered five modules are connected in series to build a holistic and systematic teaching system.**

***Index Terms*—five in one, teaching content reconstruction, scenario clue**

I. Introduction

The Mechanical Foundation Series is a compulsory basic course for mechanical majors. It covers a wide range of courses, including mechanical drawing, mechanical principles, mechanical design, mechanical manufacturing foundation, engineering materials and tolerance technology measurement [1]. It is a learning process for mechanical students in universities. Whether a student can understand, learn thoroughly and apply them is the key to the transformation of a student into a professional and technical talent. But these courses are abstract in theory, rich in concepts and strong in practice. It is difficult for students to have a good grasp of them in the process of learning [2]. Moreover, they have a long period of linking up the courses and the contents are easy to forget, which makes it difficult for students to understand and master the contents of the courses [3].

This paper takes the reducer design project as the main line, combines engineering graphics, mechanical design foundation, mechanical manufacturing foundation, interchangeability and technical measurement, engineering mechanics classroom theory teaching and mechanical design basic curriculum design practice teaching links synchronously, students learn theory courses with practical engineering problems. To carry out the research and practice of "goal-oriented, task-driven" teaching mode, realize the educational process of simultaneous learning, research and practice, stimulate students 'thinking interest and design enthusiasm, and promote students' all-round development.

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II. Building A Five-in-one Curriculum Architecture

Engineering Graphics, Machinery Design Foundation, Machinery Manufacturing Foundation, Interchangeability and Technical Measurement and Engineering Mechanics courses are the main courses of the mechanical profession. Most of the courses are based on the subject-based teaching model. Each course is self-contained and pursues the systemic and completeness of its own system. However, it ignores the comprehensive utilization of knowledge and restricts the cultivation of practical ability.

This paper breaks through the non-systematic and fragmented nature of the traditional content of the mechanical basic series courses, and builds a new curriculum system framework based on the reducer design project. It highlights the overall view, system view, innovation concept and development concept of machinery, and expands the teaching content of engineering graphics, mechanical design foundation, mechanical manufacturing foundation, interchangeability and technical measurement, and engineering mechanics into five modules from the perspective of overall and system. Construct a "five in one" curriculum system, that is, a five-course theoretical course and a practical course system. Fig. 1 is the Five-in-one curriculum system. The new curriculum system is more in line with the engineering practice and the law of talent training, which fully reflects the gradual and progressive development of students' mechanical design ability.

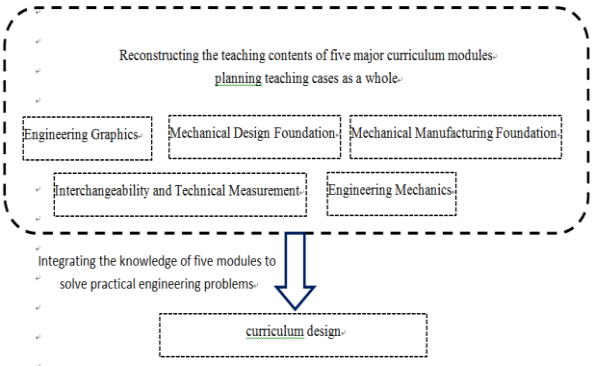

Figure 1. Five-in-one curriculum system.

The design of the reducer includes the design of basic general-purpose parts in mechanical parts, and is a comprehensive application of the mechanical foundation

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series. With the design of the reducer as the main line, the engineering graphics course guides students to draw the assembly drawings and parts drawings of the reducer. The interchangeability and technical measurement courses guide students to carry out the dimensional accuracy and coordination design of important parts in the reducer to determine the important parts. Geometrical tolerances and surface quality requirements, the Engineering Mechanics course guides students to the force analysis of important parts (especially gears) in the reducer. The mechanical design basic course guides students to the structural design and strength design of the reducer, Mechanical Manufacturing Course guides students to design and formulate technological rules for typical parts of reducer.

Through reconstructing the teaching contents of the five modules, planning teaching cases as a whole, and taking the design of reducer as a scenario clue, the teaching contents of the five modules of the leading and dispersing courses are connected in series to construct a holistic and systematic teaching system. students not only can use and consolidate their theoretical knowledge, facilitate the comparison of schemes, the selection of parameters and the analysis of results, but also can understand that when they are engaged in mechanical design, they must comprehensively consider the problems of strength, stiffness, structure, technology, assembly, lubrication, sealing and economy.

III. Reform of Teaching Mode

Teachers should "have students in their eyes, content in their hearts, artistic conception in their minds and passion in their mouth" in every lesson. Firstly, a solid foundation is the prerequisite for teachers to control the classroom. In order to achieve the goal, teachers should constantly strengthen their self-cultivation, be able to release, and be able to receive back; secondly, exquisite teaching art reflects the ability to control the classroom, good methods can attract students in the classroom, improve their interest in learning; thirdly, integrating theory with practice, teaching and engineering practice. Inter-combination will have a certain role in promoting students' learning.

In order to gradually realize the innovative teaching mode with students 'development as the center, ability training as the focus, learning results as the guide and continuous improvement, the following four main measures have been taken [4].

(1) The teaching mode of "flipping classroom". The "Internet + Teaching" mode makes it possible to adopt the "flip classroom" characterized by learning first and then teaching. In the course of teaching, the interaction between teachers and students through the network can break through the limitation of time and space in the classroom. Students can communicate with their classmates and teachers anytime, anywhere and at will. Teachers can answer questions and give guidance to students at any time through mobile terminals. Teachers are no longer just imparting knowledge to students, but also providing links to learning resources, stimulating students 'interest in learning, leading innovative thinking and logical thinking. Students can learn what they want to learn in the classroom, through the image of the animation and voice in the online course to solve the learning doubts in happiness, will greatly improve students' learning initiative and enthusiasm. Fig. 2 is Reversal Classroom Teaching Model.

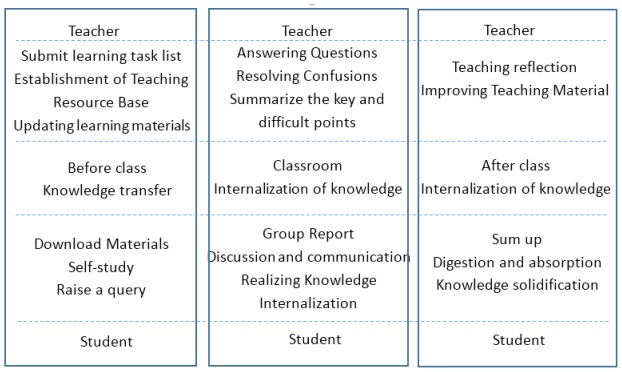

Figure 2. Reversal classroom teaching model.

(2) Heuristic teaching to improve students 'interest. In the process of teaching, teachers adopt heuristic teaching mode according to the syllabus of the course and the learning rules of students, inspire students 'thinking, and promote students' innovative thinking and learning autonomy. For example, when learning the characteristics of connecting rod mechanism, the working principle and mechanism of radar pitching mechanism, inertia screen linkage mechanism, crane mechanism, etc. can be explained; when analyzing the cam mechanism to achieve the expected movement law, the feed mechanism of machine tool and valve opening and closing mechanism of internal combustion engine can be listed; when explaining the fixed transmission ratio of gear mechanism, the fixed transmission ratio of watch can be illustrated; when the incomplete gear mechanism is analyzed, the fixed transmission ratio of watch can be given. The principle of carry in counter such as gas meter and electric meter can be enumerated. This can not only let students understand the working principle of common institutions in life, but also make students curious about the principle of machinery [5]. For example, when teaching "matters needing attention in calculating the degree of freedom of planar mechanism", we should change the teaching process from telling the matters needing attention to first to calculating the degree of freedom of mechanism to drawing the correct conclusion: first, let students calculate the degree of freedom of mechanism to get the wrong result (problems occur, cause intentional attention), and then animate the movement of the demonstration mechanism (confirming mistakes, arouse the excitement of brain cells) [6]. Then it briefly describes the matters needing attention (the key to the problem), and finally the degree of freedom of the computer organization (the test of solving the problem, surprising).

In the teaching of basic course design of mechanical design, students understand the structure, working principle and design steps of gear reducer through

physical objects, models and pictures, and how to use these knowledge to design, but they don't know where to start [7]. We design several enlightening questions around the theme of how to change a set of data given by belt conveyor design requirements into design drawings: which parameters are required by the design requirements for a given set of data in the calculation of later formulas? How to embody these parameters in the gear reducer? How to convert these parameters into the design of belt transmission, gear transmission and transmission shaft, for example? How to calculate the parameters and structure design of belt drive, gear drive and transmission shaft? Through the proposition of these questions, students can connect the isolated theoretical knowledge they have learnt, and the design idea is clear. Moreover, through the design process, they can really understand the design principles, methods and steps of machinery, which cannot be achieved through several theoretical lessons.

(3) Evolution guidance to improve knowledge cascade. There is a great continuity between mechanical basic courses, such as the motion analysis of mechanism as the practical application of the base point method and the motion synthesis of points in theoretical mechanics. The continuity of knowledge points in the course is also strong [8]. For example, helical gear transmission can evolve from spur gear. As long as the normal parameters are taken as the end parameters of spur gears, and the helical parameters and helical angles are increased, the differences between them can be understood. Let students understand not only their commonalities but also their differences. It saves a lot of teaching time and reduces the learning difficulty of students. For ordinary worm drive (Albert worm, involute worm), as far as its principle is concerned, it can be regarded as the evolution of helical gear-helical drive-worm drive, so ordinary worm drive can still be regarded as a pair of helical gear drive in its essence, so there are also normal, end and axle planes, which are their commonness. Because of the characteristics of evolution itself, worm drive has its own characteristics. Characteristics. In this way, students can easily understand the similarities and differences between helical gear drive and worm drive, and have a clear outline of the structural parameters, failure forms and material selection principles of worm drive. Therefore, it is not necessary to introduce more design formulas when explaining in detail, as long as we focus on the characteristics of worm transmission and clarify the matters needing attention in design.

(4) Case teaching to improve students ‘innovative ability. In teaching, teachers introduce engineering cases into the classroom or guide students to look for cases in life as homework, so as to make the teaching content engineering. In the classroom, with case teaching project as the traction, by introducing the examples of application and product design of institutions in products, we can improve the richness and vividness of classroom teaching, stimulate students ‘enthusiasm for learning, and improve students' ability to integrate theory with practice, so as to induce creative thinking and break the mystery of innovation [9]. For example, the crank-rocker mechanism is explained by sewing machine, the double-rocker mechanism by landing gear, the crank-slider mechanism by crank press, the guide mechanism by cutting mechanism of Bull-Head planer, the rocker mechanism by dump truck, the gear mechanism and gear train by mechanical clocks, automobile gearbox, and the two-way moving ratchet mechanism by feeding mechanism of Bull-Head planer. By introducing the case of mechanical innovative design contest into practical teaching, from topic selection, mechanical scheme design, model making, product debugging, physical processing and manufacturing, students can understand not only the production process of products, but also the assignment of task books, information selection, design scheme (mechanism motion sketch) and parts drawings through the design and manufacture of the whole contest process. The whole process of product design, such as drawing and writing instructions, as well as the statement of the contest defense process, etc. It improves students ‘practical innovation ability and comprehensive design ability.

IV. Parallel Theory and Practice

The previous Course Project of Machinery Design was completed in two weeks at the end of the first semester of the third year, including the design of reducer structure, strength design and precision design of key components such as axles and gears. Students usually need to stay up late to complete the design task because of the large amount of tasks. Students spend most of their time in the design of reducer structure, strength design of key components such as axles and gears. They have no time to design the precision design of dimension tolerance, shape tolerance and surface roughness in detail. There are many errors, such as the dimension tolerance on assembly drawing does not correspond to the tolerance on part drawing, and the free dimension on part drawing is not marked. The surface roughness, shape tolerance and dimension tolerance on the drawing are unreasonable, and there are no errors in calculating the limit deviation of common normal in the drawing of gear parts, which affect the design quality [10].

After adopting the five-in-one curriculum structure, theoretical courses and practical courses are carried out simultaneously, and the design tasks are decentralized and centralized. Before theoretical study, students receive design tasks, attend classes with questions, design calculation and theoretical study go hand in hand. Students will complete the design or selection of flexible transmission, gear transmission, keys, shafts, bearings and other parts, precision design and strength design in the form of extra-curricular work. This process not only makes the students understand the relevant knowledge of the course more thoroughly, but also improves the students ‘ability to analyze and solve practical engineering problems by using theoretical knowledge, so that the students can get better training in computing skills, drawing level, familiarity with data and relevant standards and norms, and lay a foundation for students to

learn professional courses better and work in the mechanical industry in the future.

V. Diversified Examination Methods

Establishing an assessment method based on the objective of comprehensive knowledge application and innovation ability training. The main characteristics of this examination method are the diversity of examination forms, which include closed-book examination, reasoning, analysis and innovation examination, written examination, oral examination or reply, examination of knowledge points and case discussion, periodic evaluation and conclusive evaluation, as well as individual ability exertion and team spirit. This diversified examination method can not only test students 'understanding and mastery of knowledge, but also their design ability and application ability. The most important thing is to fully stimulate students' innovative ability.

Detailed evaluation criteria in the assessment methods, so that the usual results can be based on the usual classroom performance, clear students play mobile phones, sleep, late, early retirement, absence scores; teachers can ask questions in the form of classroom performance scores reflected, not only to urge students to listen carefully, teachers can also understand the extent of students' knowledge; homework teachers can be more flexible; Questions, eliminate unified answers.

The basic course of mechanical design involves the design of various types of mechanisms, such as planar linkage mechanism, cam mechanism, gear mechanism and shafting components. In the process of examination, the purpose of adding large assignment links is to cultivate students' ability to use the knowledge they have learned to design institutions. Teachers give the movement rules of the action and execution mechanism needed to be completed by the designed machine, and students complete the selection of power and materials, mechanism design, strength checking and other aspects. Take the design report as the final evaluation index to evaluate the students. Taking the National College Students' Machinery Design Innovation Competition as the carrier, taking the topics of past years as the test questions, and letting 3-4 people as a team, we can design the mechanical system design scheme and draw the mechanism motion component diagram or assembly diagram. The final design results and replies are used as the final evaluation indicators to evaluate the students. By increasing the examination of innovative design, students' innovative design ability can be improved, students' enthusiasm for innovation can be stimulated, and students 'ability to discover, analyze and solve problems can be improved.

The assessment of curriculum design combines process assessment with ultimate assessment. A defense group is composed of curriculum design teachers and engineering graphics, mechanical design foundation, interchangeability and technical measurement, and engineering mechanics course teachers. According to the results of each course, the students' normal performance is determined. According to the content of curriculum design, a defense question bank is established according to the requirements of each course. In order to make sure that students know all the details of the design and prevent the members of the same data group from plagiarizing each other, we should ask questions about the part drawings and assembly drawings of the axles and gears. It has trained students 'language organizing ability, oral expression ability and comprehensive ability of knowledge application. Through the defense, the relevant teachers can also understand the degree of students' knowledge mastery and the ability to use it in practice, so as to arrange the teaching content and hours more reasonably and improve the teaching quality.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

E. Tian conducted the research on the "five in one" curriculum system; E. Tian had approved the final version.

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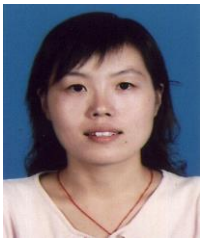

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