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Research on Teaching Methods of New Energy Vehicle Technology Major Courses for Vocational Education Undergraduates

WANG Dong-yang, DENG Zhi-jun, LI Zhan-yu, PAN Hao,
CHENG Zheng-kun, ZHANG Ya-chen
Shenzhen Polytechnic University, Shenzhen, China
WANG Peng
China Automotive Engineering Research Institute Co., Ltd., Chongqing, China

The development of new quality productivity in the new energy vehicle industry will help promote the upgrading of the new energy vehicle industry, stimulate technological innovation to improve the functions, performance, and quality of the vehicle, and maintain an advantageous position in the fierce market competition. Cultivating professional talents is the key to maximizing the development of new quality productivity in the new energy automobile industry. The core courses of new energy vehicle technology majors such as "Electric Vehicle Comprehensive Performance Detection and Evaluation", "Drive Motor and Its Control Technology", and "New Energy Vehicle Design" involve mechanics, electronics, electromagnetism, electrochemistry, and mathematics. These courses have many concepts, relatively abstract principles, multiple dimensions of performance curve analysis, and complex index evaluations. It is difficult for the traditional teaching model to achieve the purpose of enabling students to master theoretical and practical knowledge at the same time. Through the course construction and teaching of the above courses, an iterative method of concretization and dataization is proposed. First, the complex working principles are concretized to assist students in understanding. On the basis of concretization, the practical evaluation which links the target performance of automobile development process and the actual performance of the vehicle is proposed, and the concrete principle knowledge involved in design and development is turned into data, and the performance test curve and performance curve are combined through performance test experiments to comprehensively improve students' familiarity with

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WANG Dong-yang, Ph.D., Lecturer, College of Automotive and Transportation Engineering, Shenzhen Polytechnic University, Shenzhen, China.

DENG Zhi-jun, Professor, College of Automotive and Transportation Engineering, Shenzhen Polytechnic University, Shenzhen, China.

LI Zhan-yu, Associate Professor, College of Automotive and Transportation Engineering, Shenzhen Polytechnic University, Shenzhen, China.

PAN Hao, Associate Professor, College of Automotive and Transportation Engineering, Shenzhen Polytechnic University, Shenzhen, China.

CHENG Zheng-kun, Ph.D., Lecturer, College of Automotive and Transportation Engineering, Shenzhen Polytechnic University, Shenzhen, China.

WANG Peng, Senior Engineer, China Automotive Engineering Research Institute Co., Ltd., Chongqing, China.

principles and understanding of the performance. Improving the training quality of students majoring in new energy vehicle technology is to better meet the needs of the rapid development of the new energy vehicle industry.

Keywords: new energy vehicle engineering, new quality productivity, talent training, curriculum construction

Introduction

The 2024 Government Work Report shows that important progress has been made in the construction of my country's modern industrial system. And, in China, automobile industry has developed rapidly, and the new energy vehicle production and sales account for more than 60% of the world's total. Multiple documents issued by the government this year clearly stated that we should vigorously develop intelligent network technology and consolidate the leading advantages of the new energy vehicle industry. The new energy automobile industry is a comprehensive terminal industry integrating energy storage technology, electronic control technology, advanced manufacturing, and many other new technologies. Relying on technological innovation, new energy vehicle industry of China has achieved overtaking in corners and has taken a leading position in the global new energy vehicle market. It is a representative of shaping new quality productivity.

The characteristics of vocational undergraduate education include undergraduate-level education, vocational education attributes, and the integration of industry and education. It emphasizes the cultivation of professional competencies, and focuses on practical teaching and in-depth cooperation with enterprises to meet the needs of the industry (Zhang, Pan, Mu, & Jiao, 2024; Zhang, Wang, & Luo, 2024). At present, in the context of the demand for new quality development forces, the new energy automobile industry has gradually increased its requirements for practitioners. It has gradually shifted from focusing on mechanical design in the early stage to control and optimization design. With this, the comprehensive quality and professional theoretical depth of students have gradually increased. The requirements are also gradually increasing. Therefore, the traditional training objectives of mechanical design engineers and mechanical maintenance engineers, which focus on structural principles, need to be changed. In addition, the training of talents in the automotive industry under the background of new quality productivity is not a short-term intensive training of corresponding professionals. The sustainability of students' promotion abilities needs to be taken into consideration. On the basis of considering students' professional competency, according to the characteristics of vocational undergraduate students, it should carry out the output of hierarchical and classified talents.

Problems existing in the current professional training of new energy vehicle technology: Some course content focuses too much on traditional fuel vehicles, and the teaching model and curriculum structure are still based on traditional fuel vehicles. New energy vehicles are a combination of electrical, mechanical, electronic, materials, and control. Part of the technical development of subject technology products comes from traditional fuel vehicles, but its technology development system is quite different from that of fuel vehicles, especially for hybrid models that are currently hot on the market. In the current teaching process, for engines, motors, and decelerators, it mainly uses VR technology to produce animations to explain the structure and principles of the above key components. For some knowledge points involving machinery and fluids that are easy to visualize, VR technology is also used. With the blessing, students can easily understand the knowledge. However, some abstract knowledge points involved in new energy vehicle technology, such as electric fields, magnetic fields, and electromagnetic interference, which are abstract but important to new energy vehicles, are difficult to describe through VR simulation animations. It is easy for students to prefer to stay in the stage of concrete and easy-to-achieve knowledge when learning knowledge. However, knowledge points that are easy to concrete are already a lower threshold for entering new energy vehicle technology. Just mastering this kind of knowledge will not affect the follow-up of students' work. Development ability is greatly restricted (Ding & Wu, 2024; Wang & Fu, 2024; Feng & Zeng, 2024). In addition, the technology cost is too high: For different models of new energy vehicles, different concrete simulation models need to be developed and equipped with corresponding VR equipment. The development and maintenance costs of these VR equipment are high. Lack of sense of interaction: Current VR technology can already achieve basic interactive operations, such as gesture operations and voice interaction. However, there is still a lack of sense of interactivity in operations under the complex structure of some integrated components of new energy vehicles, and students lack the ability to operate during the operation. Due to the hand feel, the current VR teaching is limited to the general cognitive level of structural principles.

Another problem with over-reliance on concrete teaching is that students' mastery of technology relies too much on modeling software. At present, due to concrete teaching, students can easily master knowledge of structures and principles, and currently there is no need for structural knowledge. As to software, because of its early origin, there are many software for structural modeling. It is easier for students to master this knowledge through modeling methods through modeling software, and it is limited to structural modeling and simple analysis (Zhu & Zhao, 2024). At present, this skill started to develop before the development of new energy vehicle technology. In the era of traditional fuel vehicles, it has been relatively mature and has become a necessary threshold for entering the automotive design industry. With this concrete teaching method for a long time, it is easy for students to become dependent and thus ignore other theoretical but important knowledge required in new energy vehicle technological innovation.

Compared with traditional fuel vehicles, more software knowledge has been added to the technical system of new energy vehicles, and the development of this software knowledge is not just code writing in the traditional sense, but needs to be based on automobile theory. The understanding of knowledge is required to complete the development of corresponding functional software. The understanding of automobile theoretical knowledge requires a certain ability to understand abstract things, involving some complex calculation formulas. The understanding of this theoretical knowledge cannot be simply described through concrete animations, but it is necessary to quantify some index parameters, and students need to understand some index curves and judge existing problems and areas for improvement in the design based on the index curves (Zhu, 2024).

Therefore, in order to cope with the demand for professional and technical personnel in the context of the new quality development of the new energy automobile industry, it is necessary to combine concreteness and dataization with each other to achieve the purpose of improving teaching effectiveness.

Teaching Model Construction and Teaching Method Research

Analysis of the Coupling Relationship Between Concrete Teaching Content and Digital Teaching Content

There is a close internal relationship between the teaching of automobile structural principles and the teaching of automobile theory, and together they constitute an important part of the automobile technology course.

The teaching of automobile structure principles focuses on specific automobile components and systems, such as engines, electric motors, transmission systems, suspension systems, and vehicle control systems, etc., to help students apply theoretical knowledge to actual structures. By learning the structure, students are better able to understand and analyze the practical application of theoretical knowledge. Automobile theory teaching provides basic theoretical knowledge such as automobile working principles, dynamics, thermodynamics, and electrical science, laying a foundation for students to understand the structural principles of automobiles. Armed with solid theoretical knowledge, students can better understand the design and function of structures. From the perspective of the learning characteristics of undergraduate students in vocational education, students are more likely to accept processes such as automobile mechanisms, operating principles of structures, structural characteristic analysis, and structural parameter optimization. Cognition of structures and principles can be demonstrated through concrete methods such as animation. Currently, this method is also easily accepted by vocational education undergraduate students. Characteristic analysis and parameter optimization require students to have the ability to analyze charts and use basic theoretical formulas. It should carry out dynamics and kinematics modeling of the entire vehicle, and obtain a chart of the vehicle characteristics through simulation mode, forming a digital form, and complete the analysis of the vehicle characteristics based on the data.

By combining the two studies, students can develop the ability of comprehensive analysis and understand the influence of various components on the overall function and performance of the car. This kind of systematic thinking cultivation is not only helpful for the early design of the vehicle but also troubleshooting for the later development.

Constructing a Concrete to Data-Based Teaching Model

The transition from concrete teaching to data-based teaching requires the use of appropriate transition models. Modeling and analysis using simplified diagrams of structural principles require students to have a strong theoretical foundation and transform concrete animations into visual chart data, or curve, which can not only utilize students' thinking ability of concrete learning, but also gradually bring data-based theoretical knowledge into teaching content. At the same time, the characteristic characteristics of different curves are analyzed, the changes in the curve trend are related to the structural parameters in the structural principle, and the simplified version of the concrete teaching method is used to highlight the internal relationship between the two. According to the changing rules of the characteristic curves, the theoretical expression formulas that express characteristic curves are used to connect the knowledge of structural principles and theoretical modeling knowledge to enhance students' understanding of basic theories. Cognition of structural principles and theoretical modeling can ensure that students have the design ability to realize the function of a certain component. The job requirements for students' work ability are not only the design ability for functional realization, but also the optimization ability for performance improvement. Therefore, it is also necessary to use the mutual connection of characteristic curves and performance test curves to improve students' ability to optimize component performance improvement. Based on this, this model takes the recognition of structural principles, dynamic characteristic modeling, and experimental testing as the main line, and uses multi-disciplinary integration and modular design methods to construct a concrete to data-based teaching model for new energy vehicles, as shown in Figure 1.

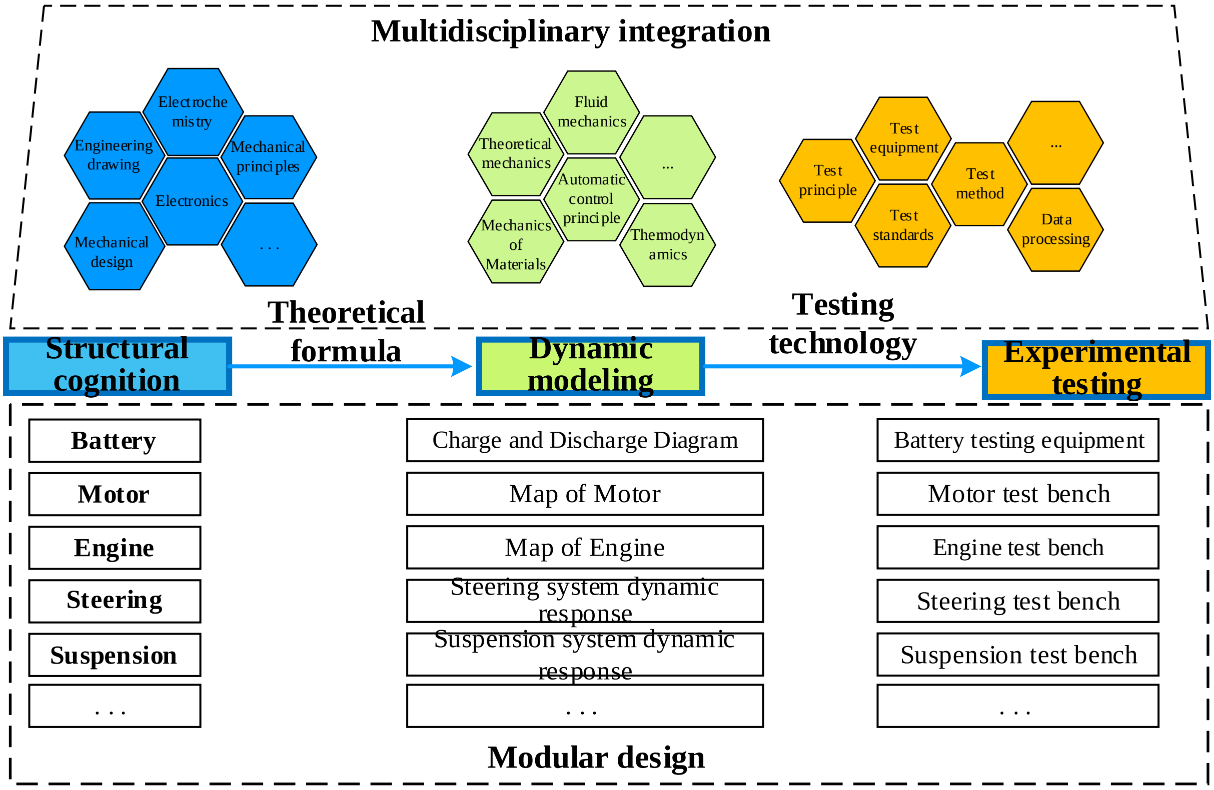

Figure 1. Diagram teaching model.

Teaching Content Construction Method

Based on concrete teaching experience, the entire vehicle is divided into main functional modules or components, and based on the divided components, it is carried out in four parts: structural principles—theoretical formulas—characteristic charts—performance verification—performance optimization. Based on the feedback from the performance verification, we can understand the structural principles and theoretical formula content again. This study divides the new energy vehicle into five basic parts: battery system, engine, electric motor, suspension system, and steering system. First, the structural principles of each key component system are explained. This part can be assisted by video animation. Then the basic theoretical formulas are introduced, and data visualization technology is used to display the characteristics of the parts represented by the basic theoretical formulas. At the same time, testing of the parts is carried out, and the experimental test data and the data represented by the theoretical formulas are compared and analyzed to deepen the understanding. The understanding of basic theoretical formulas, and the performance index data obtained through component testing experiments can optimize the performance of components from both structural and control aspects, further improving students' understanding of basic theoretical knowledge. This article takes the five key components of new energy vehicles as examples to explain the implementation of this teaching method.

1. Battery

The teaching content construction of the battery module is shown in Figure 2, which is carried out from four aspects: structural principles, theoretical formulas, characteristic curves, and experimental verification.

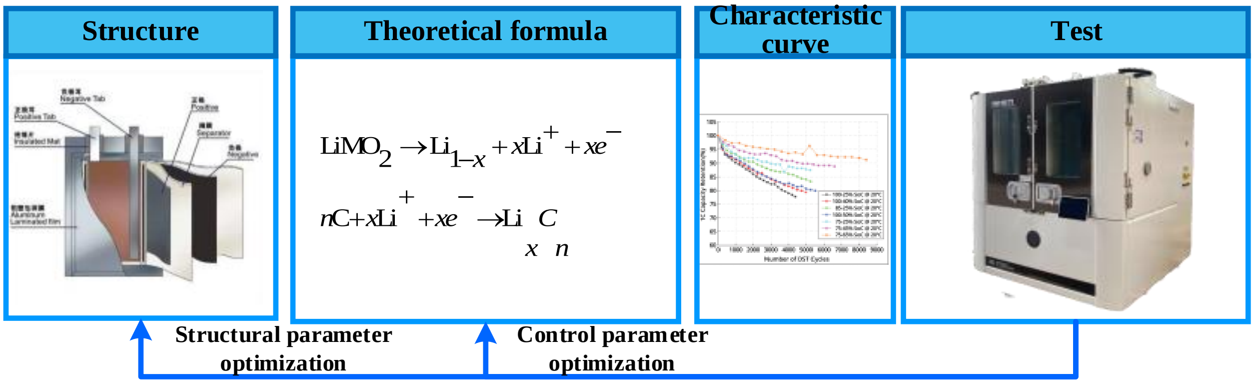

Figure 2. Teaching content of battery system.

(1) Structural principle

The basic structure of a battery includes: positive electrode (anode), negative electrode (cathode), electrolyte, and separator.

(2) Principle of chemical reaction

Charging process:

$$\mathrm{LiCoO_2} + \mathrm{C} \rightleftharpoons \mathrm{Li}_x\mathrm{C} + \mathrm{Li}_y\mathrm{CoO_2} \tag{1}$$

Discharge process:

$$\mathrm{Li}_x\mathrm{C} + \mathrm{Li}_y\mathrm{CoO_2} \rightleftharpoons \mathrm{LiCoO_2} + \mathrm{C} \tag{2}$$

(3) Charge and discharge curve test

Charge and discharge curve is an important tool to evaluate battery performance, which usually includes the following aspects: voltage curve, capacity curve, and cycle performance test.

By comprehensively understanding the structure, chemical reactions and charge and discharge characteristics of power batteries, battery design, performance evaluation, and application optimization can be better carried out.

2. Engine

The construction of the teaching content of the motor module is shown in Figure 3, which is carried out from four aspects: structural principles, theoretical formulas, characteristic curves, and experimental verification.

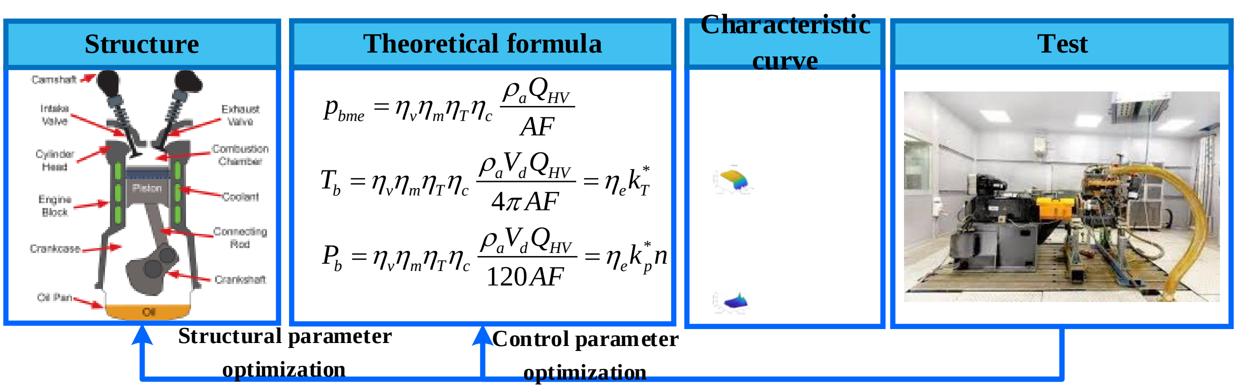

Figure 3. Teaching content of engine.

(1) Structure

The engine is mainly composed of the following key parts: cylinder; piston; crankshaft; valve; cylinder head; air lubrication system.

(2) Principle of torque generation

The torque of a four-stroke engine is mainly generated by the movement of the piston and the rotation of the crankshaft. The torque of the engine is determined by the combination of the force generated during the working stroke and the piston stroke, and is usually measured within a specific angular range of the crankshaft rotation.

(3) Bench test

Bench testing of four-stroke engines is used to evaluate its performance and torque output, mainly including the following aspects: power test, torque curve, fuel consumption test, emission test, and durability test.

Through a comprehensive understanding of the structure, torque generation principle, and bench testing of four-stroke engines, it can provide important basis for the design, optimization, and performance evaluation of the engine and help improve its overall performance and reliability.

3. Motor

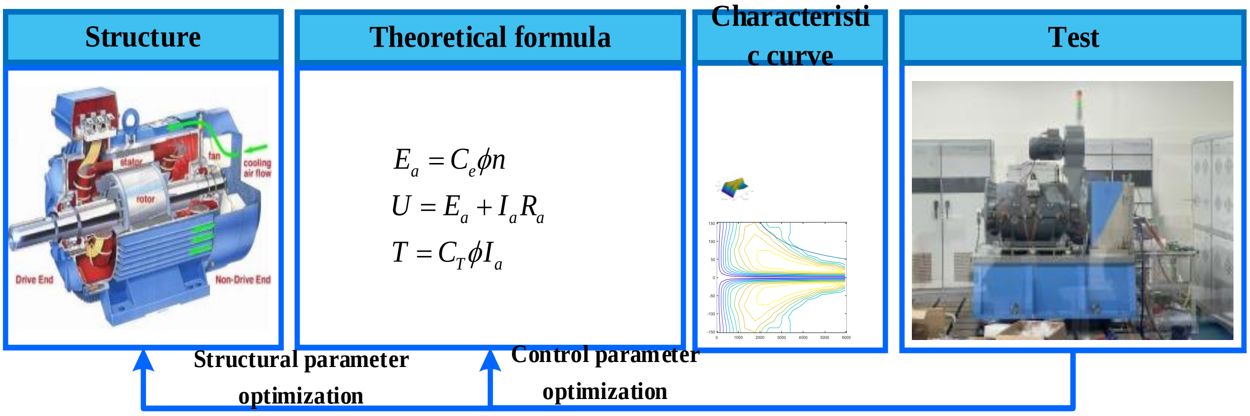

Figure 4. Teaching content of motor.

(1) Structure

The basic structure of an electric motor usually includes the following main parts: stator, rotor, air gap, shaft, and fan or cooling device.

(2) Principle of torque generation

The torque generation principle of the electric motor is mainly based on the action of electromagnetic induction and Lorentz force: Its calculation formula is:

$$T = kIBL .$$

Among them, k is the coefficient, T is the torque, I is the current, B is the magnetic field strength, and L is the conductor length.

(3) Bench test

Bench testing of electric motors is used to evaluate their performance, including the following aspects: power testing, torque curve, efficiency testing, temperature rise testing, noise and vibration testing, and thermal testing.

A comprehensive understanding of the motor's structure, torque generation principle, and bench testing can provide an important basis for the design, optimization, and performance evaluation of the motor, helping to improve its overall performance and reliability.

4. Suspension system

The teaching content construction of the suspension system module is shown in Figure 5, which is carried out from four aspects: structural principles, theoretical formulas, characteristic curves, and experimental verification.

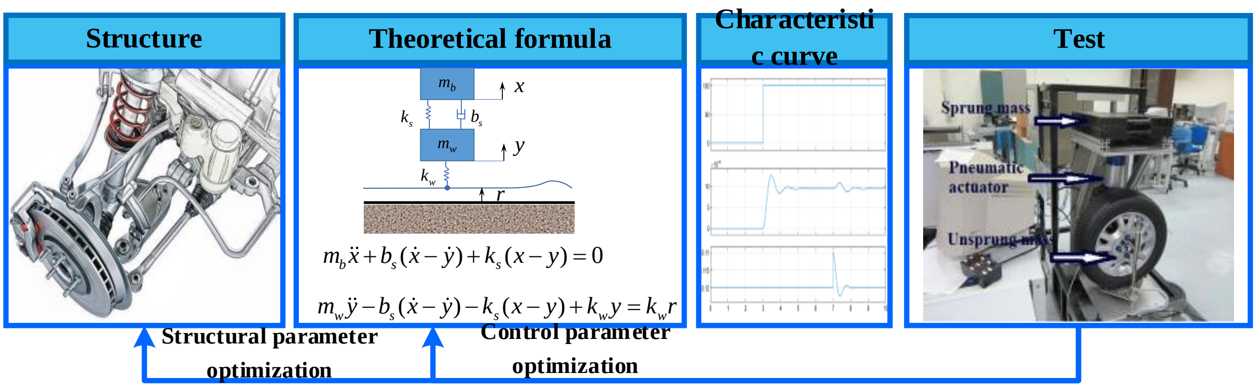

Figure 5. Teaching content of suspension system.

(1) Structure

The vehicle suspension system mainly consists of the following key components: springs, shock absorbers (dampers), control arms, steering knuckles, and stabilizer bars.

(2) Working principle

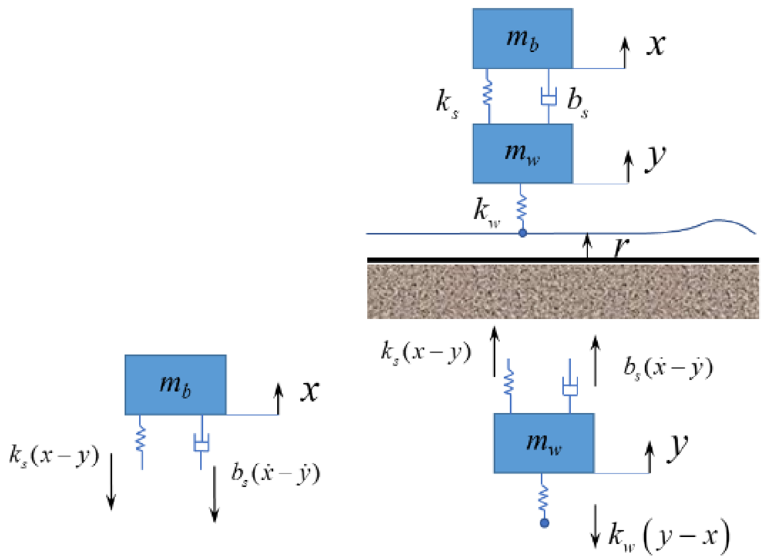

Figure 6. Model of suspension system.

The two-mass vibration model of the vehicle suspension system is an effective method for analyzing and simulating the dynamic characteristics of the vehicle suspension system. This model simplifies the dynamic behavior of the suspension by treating the vehicle as two mass blocks (body and wheels). The theoretical model is shown in Figure 6. Applying the basic mechanical analysis knowledge mastered by students, students are led to establish a theoretical simulation model (Equation 1 shown), and analyze the dynamic characteristics.

$$
\begin{aligned}
&m_b\ddot{x}+b_s(\dot{x}-\dot{y})+k_s(x-y)=0\\
&m_w\ddot{y}-b_s(\dot{x}-\dot{y})-k_s(x-y)+k_w y=k_w r
\end{aligned}
\tag{3}
$$

(3) Test bench

The test bench of the suspension system is used to evaluate its performance, mainly including the following aspects: vibration test, loading test, and fatigue test.

A comprehensive understanding of the structure, working principles, and test bench of the vehicle suspension system can provide important basis for the design, optimization, and performance evaluation of the suspension system, helping to improve the vehicle's driving performance and ride comfort.

5. Steering system

The teaching content of the steering system module is shown in Figure 6, which is developed from four aspects: structural principle, theoretical formula, characteristic curve, and experimental verification.

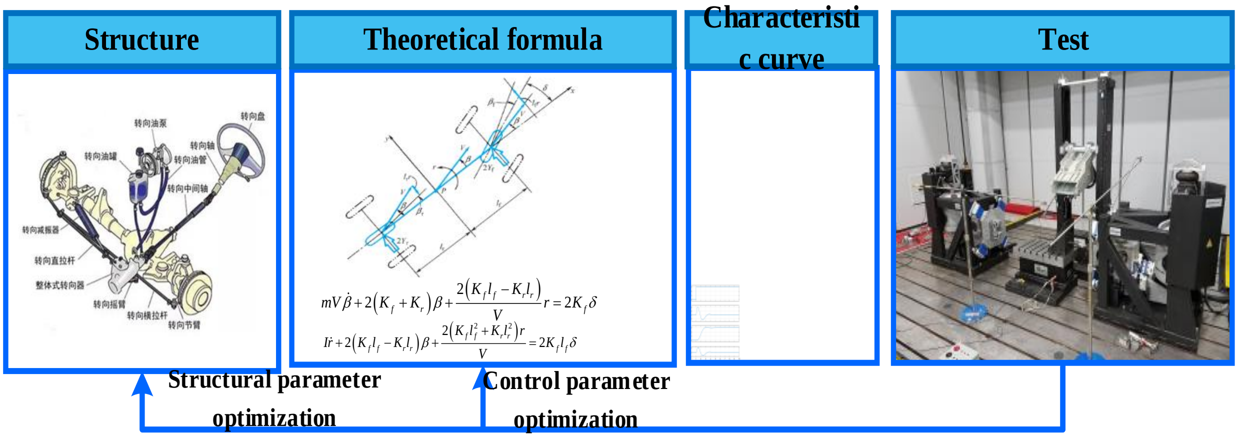

Figure 7. Teaching content of Steering system.

(1) Structure

The vehicle steering system is mainly composed of the following key components: steering wheel, steering column, steering gear, steering tie rod (connecting rod), ball joint and tire and steering knuckle.

(2) Working principle

The working principle of the vehicle steering system mainly includes the following aspects: Steering wheel input: The driver generates an angle by turning the steering wheel and transmits it to the steering column. Steering gear conversion: The steering column transmits the rotational motion of the steering wheel to the steering gear, which converts the rotational motion into linear motion to control the rotation of the wheel. Wheel steering: The steering gear transmits the motion to the front wheel through the connecting rod, so that the wheel turns according to the driver's intention. Feedback mechanism: During driving, the vehicle's driving state and road conditions will be fed back to the steering wheel, and the driver can feel the road information to improve driving stability and safety.

(3) Test bench

The test bench of the steering system is used to evaluate its performance, mainly including the following aspects: steering accuracy test, durability test, load test, vibration and noise test.

By comprehensively understanding the structure, working principle, and test bench of the vehicle steering system, it can provide important basis for the design, optimization, and performance evaluation of the steering system, and help improve the vehicle’s handling performance and safety.

Data-Based Teaching and Concrete Collaborative Teaching Methods

The basis for the integration of data-based teaching and concrete teaching is the visualization of structural principle animation and the visualization of theoretical formula data. The key is to relate and integrate the two images, and guide students from the learning habits of familiar concrete animation to the learning habits of digital learning. In this teaching stage, the case teaching method based on the engineering practice path is carried out. Based on the new energy vehicle development process, the above-mentioned basic parts development is used as an engineering case, and case teaching is carried out from four aspects: structural design, performance analysis, performance verification, and optimization. In the development case of the automobile steering system in the mini-semester course of the new energy automobile technology major, students first learn about the structural principles of the steering system, use 3D design software to complete the design of the steering system, and then build a steering system simulation model based on the steering system principle to analyze the performance of the steering system. With the help of the steering test bench, the performance of the steering system is tested, and finally the parameters of the steering system are optimized again according to the test results. Through the entire engineering practice path, students have mastered the theoretical knowledge and experimental methods, and further enhanced their understanding of knowledge.

Course Teaching Evaluation

The course teaching method design involves basic principle knowledge and experimental tests, and it is necessary to design a diversified evaluation system. This evaluation includes not only theoretical examinations, but also project completion, experimental reports, and teamwork ability. It conducts a process evaluation of students’ comprehensive learning effects from multiple aspects to achieve the purpose of improving teaching effectiveness.

Conclusion

This study proposed a method that combines concrete teaching with data-based teaching for undergraduate new energy vehicle technology courses in vocational education, aiming to improve students’ ability to transition from the understanding of structural principles to the mastery of basic characteristic analysis and performance testing knowledge, and to cultivate students’ design and development capabilities from mastering function implementation design to performance optimization design, in order to better meet the new energy vehicle technology industry’s demand for new energy vehicle technical talents under the background of the development of new quality productivity.

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