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A Study on Teaching Design and Implementation of Automobile Practical Course Based on Project Teaching

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Abstract: Following the proposal of the "Emerging Engineering Education (EEE)" initiative, the cultivation of interdisciplinary innovative talents has gained increasing prominence. Currently, there exists a significant gap between the practical innovation capabilities of automotive majors in vocational colleges and the evolving demands of the industry. To address deficiencies in interdisciplinary innovative talent development programs, this study proposes an educational framework structured around "One Core, Two Dimensions, Three Levels." Leveraging a project-driven teaching methodology and utilizing CATIA—the industry-standard 3D design software—as a central tool, we have developed a closed-loop teaching model integrating theory, modeling, simulation, and evaluation. This model underpins a newly designed automotive engineering practicum aimed at nurturing high-quality engineering talents equipped with three critical competencies: solving complex engineering challenges, digital design proficiency, and cross-disciplinary collaborative innovation. The proposed approach demonstrates potential to alleviate the structural disconnect between traditional engineering pedagogy and industry talent requirements.

Keywords: Interdisciplinary innovative talents; Project-driven; Practical innovation; CATIA

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1. Introduction

The rapid development of China's automotive industry and its ever-evolving industrial landscape have imposed new requirements for the cultivation of technical talents in this sector [1]. In the context of rapid advancements in industrial innovation and manufacturing, an increasing number of emerging complex challenges cannot be resolved through isolated disciplinary approaches, necessitating interdisciplinary innovators capable of adapting to the new wave of technological revolution and industrial transformation to assume critical responsibilities in production innovation [2]. Against this backdrop, vocational colleges have significantly revised their training objectives and skill requirements for next-generation automotive technicians [3], positioning educational institutions as innovative practice platforms entrusted with cultivating professionals aligned with societal development needs [4]. However, most current engineering talent development mechanisms in vocational colleges suffer from insufficient practical training, with predominant reliance on traditional teaching methods such as blackboard-based instruction and PowerPoint lectures. This approach conflicts with the interdisciplinary innovation principles emphasized in Emerging Engineering Education (EEE), while graduates' skill levels consistently fail to meet industry expectations. Amidst the accelerated growth of engineering R&D and intelligent manufacturing, engineering education must transcend the limitations of conventional pedagogy, making the cultivation of innovative talents with robust foundational knowledge and outstanding engineering capabilities a central focus of pedagogical research in vocational engineering education.

To develop interdisciplinary professionals capable of meeting automotive industry demands and bridging theoretical-practical gaps, this study integrates current employment market needs to design a practice-oriented curriculum centered on enhancing students' engineering practice capabilities, innovative thinking, and collaborative skills. Guided by the "One Core, Two Dimensions, Three Levels" pedagogical framework, the course development process involves: (1) systematic elaboration of instructional philosophies; (2) detailed curriculum design; (3) practical implementation through a case study employing CATIA for modeling and finite element analysis of a new energy vehicle's transmission solid axle; and (4) comprehensive multi-dimensional evaluation. By integrating theoretical instruction, digital modeling, software simulation, and outcome assessment within automotive design contexts, this curriculum effectively converges theoretical knowledge with practical skill development, providing innovative perspectives and implementable paradigms for vocational education reform.

2. Course introduction and teaching concept

The Automotive Design Practice Course (hereinafter referred to as "the Practice Course") is designed for final-year students majoring in Automotive Application and Maintenance and related disciplines. Integrating multidisciplinary knowledge from mechanical engineering, mechanics, and automotive engineering, this course systematically bridges theoretical foundations with practical applications to deliver comprehensive competency development. It serves a tripartite mission: cultivating professional literacy, enhancing holistic competencies, and empowering graduates for innovative career paths or advanced academic pursuits. Adopting a practice-driven approach centered on real-world engineering problem-solving, the course operationalizes the pedagogical framework of "One Core, Two Dimensions, Three Levels" to cultivate next-generation engineering innovators with interdisciplinary capabilities.

2.1. One Core

Compared to knowledge-centered curriculum development paradigms, student-centered pedagogical approaches demonstrate superior efficacy in enhancing learner engagement and knowledge acquisition. The Practice Course employs team-based learning structures where students self-organize into groups to collaboratively execute practical projects. Post-implementation, participants conduct critical self-assessments and peer evaluations through guided critical thinking exercises, emphasizing proactive participation and personalized learning trajectories to achieve iterative knowledge/skill enhancement throughout project cycles.

To investigate student preferences for instructional methodologies, a pre-implementation survey was administered to Automotive Application and Maintenance majors using a multiple-response questionnaire format. Analysis of 100 valid responses revealed distinct pedagogical expectations (as illustrated in **Figure 1**):

77% of respondents prioritized interest-driven curriculum customization, 55% endorsed self-directed research projects, while 51% emphasized hands-on involvement in full-cycle course design. These findings underscore students' strong preference for practical learning modalities that stimulate engagement while addressing multifaceted competency development needs.

Cross-analysis of learning behavior patterns examined two variables: X (post-graduation plans) and Y (problem-solving strategies). **Table 1** presents the distribution percentages of Y-variable manifestations across X-variable categories. Key observations include: (1) Predominant reliance on self-directed information retrieval when confronting academic challenges, indicating emerging self-regulated learning capabilities; (2) Significant minority preference for peer consultation, highlighting the critical role of collaborative learning ecosystems. Notably, 83% of participants advocated for personalized curricular structures, particularly interest-based course selection, providing novel insights for higher education curriculum optimization.

The survey conclusively demonstrates strong student endorsement of practice-oriented assessment mechanisms, particularly in applied disciplines. This empirical evidence necessitates pedagogical reforms prioritizing authentic learning experience design to cultivate holistic competencies. Collectively, these findings provide actionable guidelines for advancing technical education through customized curriculum development and enhanced practical training integration.

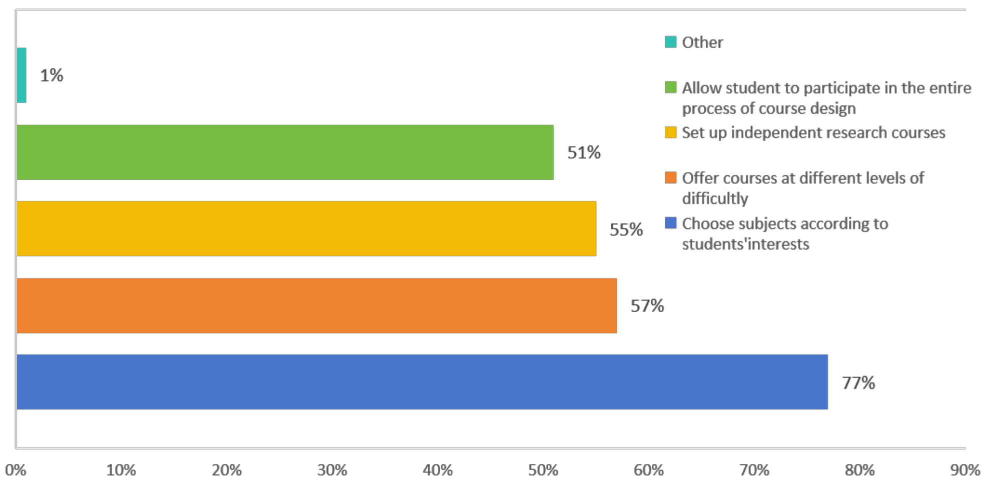

Figure 1. Students' choice of course setting method

Table 1. Analysis of learning mode data

X/Y	Look up the data by yourself	Ask students for advice	Ask the teacher for advice	Search for answers online	Give up searching for the answer	Subtotal
Further study at school	32 (88.89%)	23 (63.89%)	22 (61.11%)	24 (66.67%)	2 (5.56%)	36
Employment in relevant disciplines	21 (63.64%)	22 (66.67%)	19 (57.58%)	20 (60.61%)	2 (6.06%)	33
Employment in the direction of interest	15 (60%)	14 (56%)	15 (60%)	19 (76%)	4 (16%)	25
Other	4 (66.67%)	4 (66.67%)	1 (16.67%)	6 (100%)	0	6

2.2. Two Dimensions

Educational practice constitutes an integrative process combining knowledge impartation and holistic cultivation, emphasizing "comprehensive instructional dimensions and multidimensional talent development." The pedagogical framework advocates extensive instructional dimensions encompassing teaching modalities, methodological approaches, theoretical foundations, technical competencies, and technological applications. This multidimensional architecture enables the efficient cultivation of students' comprehensive qualities and capabilities, while the holistic developmental dimensions ensure optimized educational outcomes. The Practice Course's core philosophy synthesizes three interdependent elements: rationalized instructional methodologies, diversified delivery mechanisms, and adaptive pedagogical frameworks, collectively designed to foster students' holistic competencies and applied problem-solving capabilities.

Curriculum development adopts a problem-based learning (PBL) paradigm, specifically implementing PBL strategies to enhance deep learning and application competencies through authentic project execution. Emphasizing student-centered design, the course aligns all instructional activities with predetermined learning outcomes to ensure goal attainment. Throughout the learning process, instructors provide timely guidance and targeted instruction based on real-time student needs, maintaining continuous pedagogical engagement to stimulate proactive learning behaviors and enhance problem identification/resolution capacities [5].

Simultaneously, pedagogical flexibility has emerged as a critical curriculum design principle. The traditional lecture-dominated model, where students passively receive information through auditory and visual channels, has been supplanted by an interactive paradigm. Instructors transition from knowledge transmitters to facilitators and cognitive coaches, integrating theoretical instruction with practical projects to prevent disorientation in self-directed learning environments. Students collaborate in research teams to complete engineering projects, followed by critical self-evaluations and peer assessments using structured rubrics. A comprehensive evaluation system monitors participation and performance, ensuring universal project engagement.

Furthermore, technological diversification significantly enhances instructional effectiveness. In the Automotive Design Practice Course, students employ CATIA—the industry-preeminent computer-aided design software—to materialize theoretical knowledge through digital modeling and feasibility analyses. Utilizing the Generative Structural Analysis (GSA) module, learners conduct static and modal analyses on transmission components, thereby deepening their understanding of engineering mechanics principles.

Educators must embody lifelong learning principles by continuously updating pedagogical knowledge and technical proficiency. This commitment enables the development of personalized instructional plans tailored to individual learning profiles and the continuous evolution of specialized curricula that emphasize customized educational pathways. Such approaches not only integrate theory with practice but also cultivate interdisciplinary competencies—for instance, synthesizing mechanical engineering and applied mechanics through computer-aided automotive design. Through collaborative project execution, students develop teamwork ethos, innovative thinking, and proactive problem-solving dispositions. Ultimately, this educational model cultivates new-generation engineering professionals with social responsibility, exemplary professional ethics, and innovative capacities, thereby fully realizing the dual objectives of comprehensive instructional dimensions and holistic talent development.

2.3. Three Levels

The evolving demands of modern society and industries have elevated expectations for graduates' professional competencies and engineering literacy in higher education. To align with cutting-edge automotive industry developments, theoretical instruction and practical training must advance synergistically, ensuring comprehensive cultivation of students' innovative, creative, and entrepreneurial capabilities. This necessitates cultivating practice-oriented innovators tailored to employer requirements [6], ultimately producing interdisciplinary engineering professionals meeting contemporary industry standards. The automotive practice curriculum adopts a three-tiered pedagogical framework: "interdisciplinary knowledge integration," "industry-aligned skill development," and "practical outcome orientation."

2.3.1. Interdisciplinary knowledge integration

Contemporary engineering education increasingly emphasizes cross-disciplinary convergence, encouraging the synthesis of multidisciplinary knowledge domains. However, disciplinary integration in specialized automotive courses remains constrained by technological and methodological limitations. This instructional design bridges mechanical engineering, material science, and automotive systems through computer-aided methodologies, enabling theoretical knowledge transfer and cross-domain application.

2.3.2. Industry-aligned skill development

The curriculum implements a systematic workflow emphasizing holistic competency building. Students must demonstrate a comprehensive understanding of engineering projects—including component functionality, structural configurations, and operational principles—while attaining proficiency in parametric modeling and feasibility analysis using industry-standard tools. Through iterative design processes, learners internalize automotive engineering workflows and develop enterprise-ready technical skills.

2.3.3. Practical outcome orientation

Addressing the prevalent industry-academia competency gap, the curriculum incorporates market-driven requirements to enhance professional and engineering literacy. By integrating authentic industry challenges into coursework and fostering industry-academia partnerships, the program achieves practical outcome realization through three strategic dimensions:

(1) Convergence of theoretical and applied learning.

(2) Deepened industry-education collaboration.

(3) Enhanced employability through innovation-centric training.

Centered on active learning and personalized development, this three-dimensional framework ("Knowledge Integration-Skill Cultivation-Outcome Realization") synergizes academic knowledge transfer, industry-specific competency building, and practical innovation. It ultimately cultivates ethically grounded engineering professionals with robust technical expertise and creative problem-solving capacities, achieving dual advancement in pedagogical effectiveness and holistic talent development through deep integration of theoretical mastery and practical application.

3. Curriculum design

This course revolutionizes conventional pedagogical models by adopting a student-centered approach where instructors serve as cognitive facilitators [7]. Through sustained dialogic engagement during project execution, the program cultivates advanced interdisciplinary engineering professionals equipped with independent critical thinking and engineering problem-solving capabilities.

3.1. Computer-aided design

The core of the practical course lies in comprehensively and systematically enhancing students' comprehensive competencies. To this end, the instructional design of the practical course requires deep integration of computer-aided analysis software as the practical carrier. By constructing virtual models through a virtual simulation platform, relatively two-dimensional theoretical knowledge is transformed into actionable project cases. This professional software-based practical teaching model not only strengthens students' technical operation proficiency but also cultivates their team collaboration skills and critical thinking through real-scenario teamwork.

3.2. Course objectives

The practical course of automotive design teaching is student-centered, integrating various teaching methods, starting from the needs of enterprises, in order to cultivate high-quality engineering talents needed by enterprises and provide strong support for the training of automotive professionals. The training objectives of this course are to master the main structure and body structure of automobiles, familiarize oneself with the working principles and coordination principles of various components of automobiles, learn the basic process of design and modeling, cultivate the ability to use computer software to solve problems, preliminarily master the CATIA software for automobile parts modeling and simulation modules, and be able to model and simulate basic automobile parts through static and modal simulation. After the course, students should be able to independently apply their professional knowledge, solve relevant problems in practical production or scientific research, and improve their ability to integrate theory with practice and innovation [8].

3.3. Course setup

Based on the course objectives, the teaching design process of this practical course is shown in **Figure 2**.

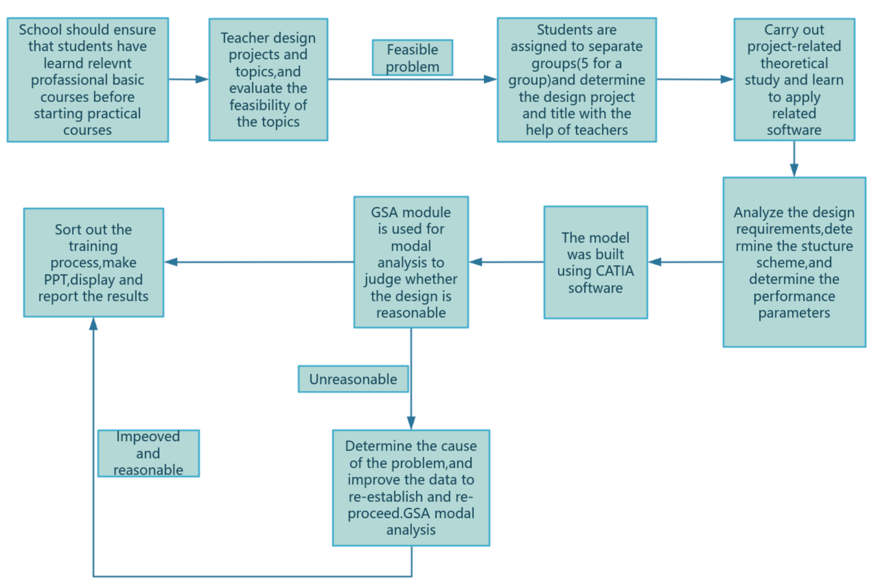

Figure 2. Teaching design process

The design duration of the teaching practice section is four weeks, including topic selection, teaching, practice, and achievement verification. Before conducting this practical course, the school should ensure that the students in the class have completed professional basic courses such as automotive structure and automotive mechanical foundation, as well as the basic application of relevant computer design software. The course adopts a project-based learning model, where students independently form project teams and complete the entire development process from requirement analysis, scheme design to model production under the guidance of teachers. During the implementation process, a full process assessment mechanism is established. Teachers conduct comprehensive assessments by observing students' enthusiasm, project participation, and other situations. Through role rotation within the group, all members are ensured to deeply participate in key aspects. Finally, a three-dimensional evaluation system of "model display, process report, and defense statement" is used to focus on testing students' ability to use computer-aided tools for engineering expression. At the same time, a student group peer review section is set up to strengthen the cultivation of students' critical thinking.

The specific steps for conducting the course are as follows:

(1) Distribution of the task book. In the first four class hours after the start of the course, a course design task book will be issued, and the teacher will explain the content of the task book. Students are required to independently search for relevant materials to deepen their understanding of the basic composition and working principles of automotive components; Understand the purpose of using computer design software; Students will be divided into groups of five to conduct modeling and simulation of an automotive component, and write a related engineering report at the end of the course.

(2) Design of components. Select models for automotive components, use CATIA software to draw the components, and after drawing, submit them to other groups for mutual evaluation and to teachers to assess whether the component size settings are reasonable. After that, set the materials accordingly. Students should consult relevant literature on their own to strive for the rationality and professionalism of the component settings.

(3) Simulation analysis of components. Apply the Generative Structural Analysis (GSA) module in CATIA software to perform static, modal, and other analyses on the model. Firstly, perform grid partitioning by subdividing the heavily stressed areas, reducing the grid size appropriately. Then, hide the grid and set constraints and distributed forces. By consulting relevant materials, set appropriate force points and constraint sizes, and calculate the simulation results. In this section, translational displacement vector analysis and equivalent stress analysis can be performed simultaneously.

(4) Project acceptance and defense. The final 8 hours of the practical course will be used for project acceptance and group defense. The establishment of components, simulation, production of engineering reports, and presentation of defense PPTs are all scoring criteria; In the defense session, each group selects one student and teacher to form a defense group, which will ask project questions to each project group, including but not limited to the reasons for selecting components, problems in the design process, project division of labor, data in the engineering report, and professional knowledge learned.

4. Presentation of results

Taking the design and simulation of the solid shaft part of a new energy passenger vehicle transmission shaft done by a student project group as an example. **Figure 3** shows an example of a car transmission shaft.

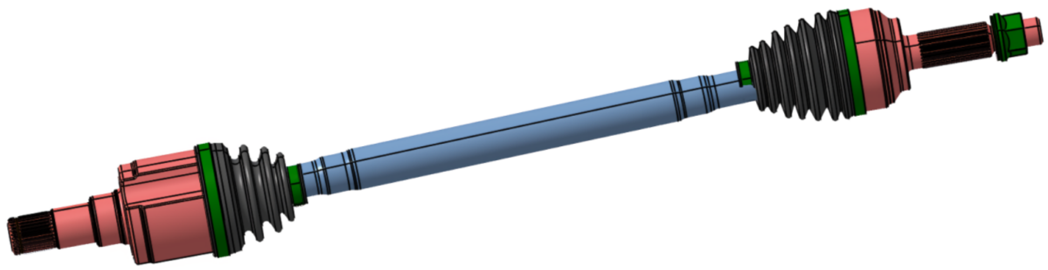

Figure 3. Automotive transmission shaft

4.1. Design phase

After studying basic theories and selecting topics with the assistance of teachers, students need to establish simulation models. As the core functional unit of the vehicle power transmission chain, the automotive transmission shaft system undertakes the dual mission of engine torque transmission and speed regulation. Among them, solid shaft components exhibit irreplaceable load-bearing advantages in the power transmission path due to their continuous, homogeneous cross-section structural characteristics. The student group designed the solid shaft part of the transmission shaft as shown in **Figure 4**.

Firstly, determine the input parameters of the car, as shown in **Table 2**.

Table 2. Parameters of transmission shaft

Input parameter	Power (P)	Rotating speed (n)	Shaft length (L)	Service environment
Value	120 kW	2000–3500 N·m	1.2 m	Room temperature, no corrosion

The commonly used materials for automotive transmission shafts are carbon steel, alloy steel, and stainless steel. The team designed a solid shaft for the transmission shaft of household economy cars, selecting 45 steel specified in the GB/T 699-2015 standard as the basic material with good comprehensive mechanical properties and low cost, and implementing quenching and tempering treatment process (850°C quenching + 600°C high-temperature tempering).

Calculation of transmission shaft torque:

$$T = 9550 \times \frac{P}{n} = 327.429\text{-}573 N \cdot m$$

Compliant with the torque range of passenger cars (200–600 N·m).

Calculate the preliminary design shaft diameter based on the torsional strength formula. The formula for torsional stress is as follows:

$$\tau = \frac{T}{W_p} = \frac{16T}{\pi d^3}$$

Where W_p is the torsional section modulus, d is the shaft diameter, the allowable torsional stress standard of 45 steel modulation material is 120–160 MPa, and the shaft diameter is preliminarily designed as 30 mm by inversely pushing and rounding the formula.

The torsional angle formula is:

$$\theta = \frac{T \cdot L}{G \cdot J} \leq 0.108$$

Where L is the shaft length, G is the shear modulus (steel ≈ 80 GPa), J is the polar moment of inertia, and the allowable angle of twist is generally ≤ 0.25–1.0 °/m.

Calculated values are within a reasonable range. The main purpose of this design is to let the higher vocational students learn the basic process of design modeling, train the ability to solve problems with computer software, and preliminarily master the modeling and simulation module of auto parts with CATIA software. Therefore, the analysis under different working conditions is not carried out in this study.

Figure 4. Solid shaft

4.2. Simulation analysis

The learning group adopts 45 steel as the basic material and implements the quenching and tempering process (850°C quenching + 600°C high temperature tempering). As shown in **Figure 5**, the solid axis is modeled by finite element analysis with a non-uniform grid division strategy, and the critical stress area is refined by local grid refinement technology to achieve a balance between calculation accuracy and efficiency. Fixed constraint and radial load boundary conditions are applied according to the basic working condition of the transmission shaft, and the specific loading scheme is shown in **Figure 6**.

The static analysis module based on the finite element method can effectively evaluate the mechanical response characteristics of mechanical components under multiple loads [9]. Based on the engineering practice of automobile transmission shaft bearing bending load in working process, the learning group applied a 1000 N uniformly distributed load on solid shaft under fixed constraint conditions, and the system acquired three key mechanical parameters: displacement field distribution, equivalent stress nephogram, and displacement vector field distribution (**Figure 7**). The equivalent effect force nephogram can directly reflect the potential failure area of the component, and the displacement vector field quantitatively characterizes the maximum deformation direction, which provides a theoretical basis for structural optimization.

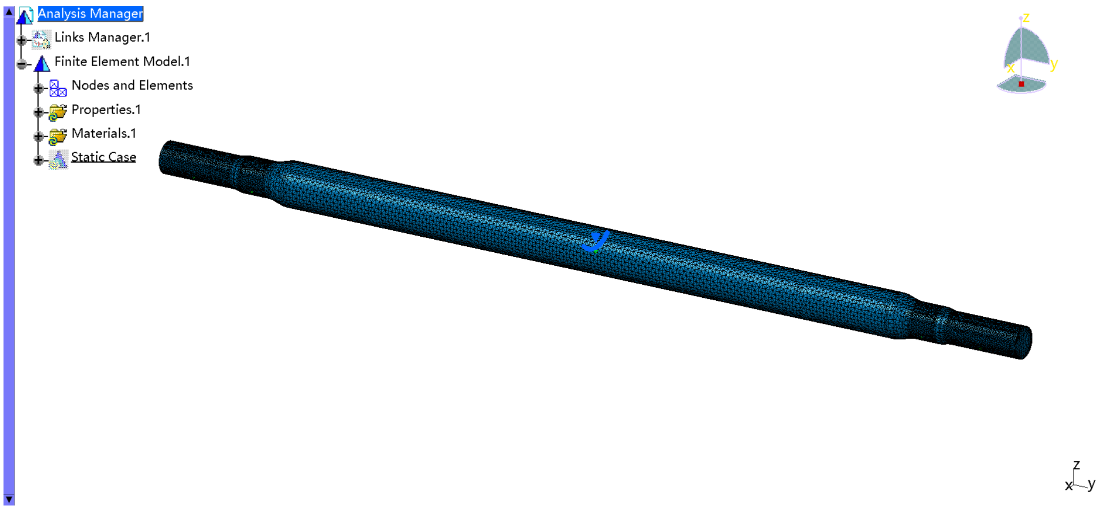

Figure 5. Grid division

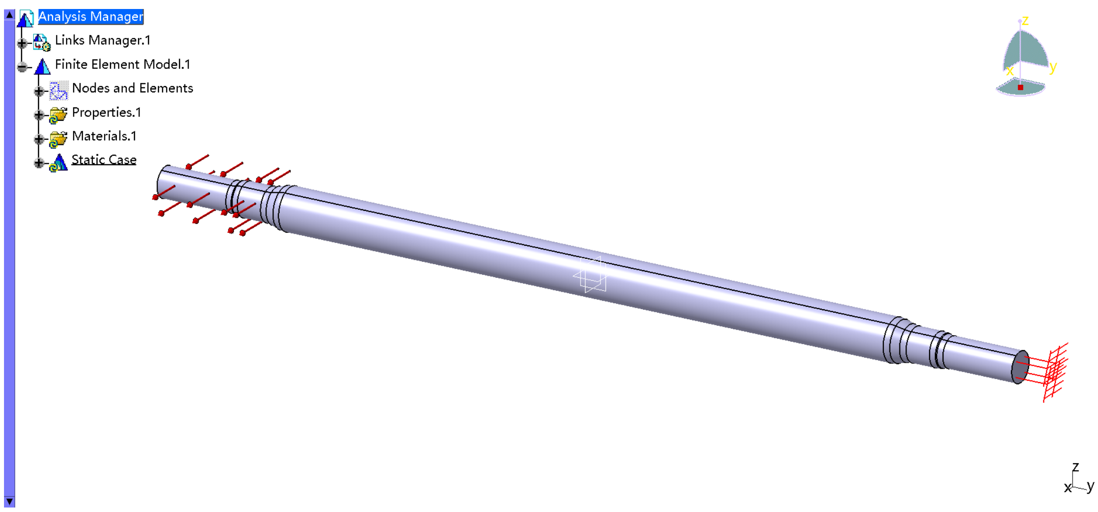

Figure 6. Load and restraint on solid shaft

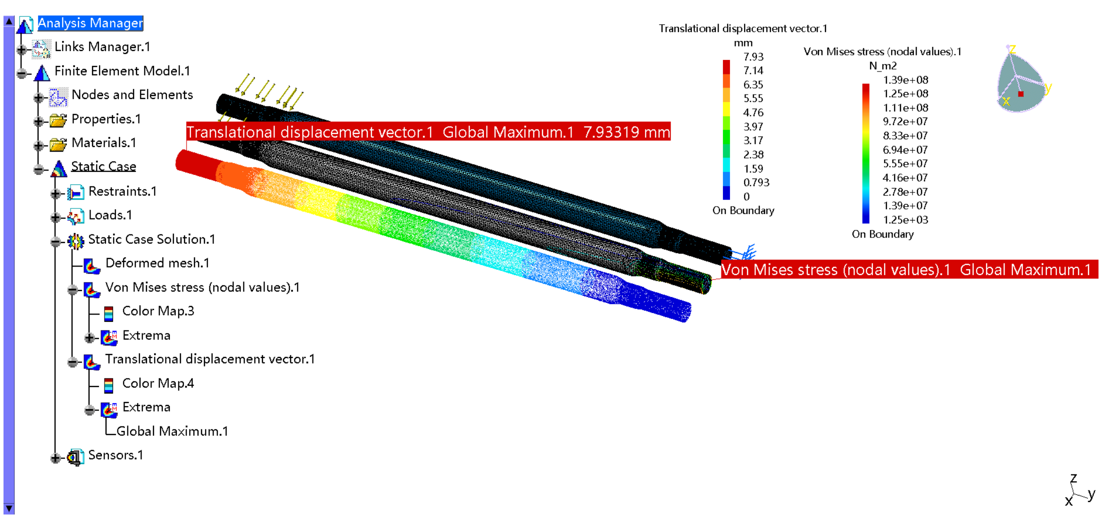

Figure 7. Graphical representation of static analysis

4.3. Analysis report

Basic parameters of the designed solid shaft are shown in **Table 3**.

Table 3. Basic parameters

Material	45 steel
Young's modules	2×10^{11} N/m^2
Poisson's ratio	0.266
Density	7860 kg/m^3
Coefficient of thermal expansion	1.17×10^{-5} K^{-1}
Yield strength	2.5×10^{8} N/m^2

Based on the finite element calculation results (as shown in **Table 4**), the displacement constraint reaction of the key nodes of the transmission system presents significant non-uniform distribution characteristics. In the Tx (transverse translation) and Tz (axial translation) DOF directions, the maximum constraint reaction values 5.84×10^5 N (Tz direction) and 7.49×10^5 N (Tx direction) are detected at node 254907 respectively, and the spatial coordinates are concentrated in the (-14.77, -531.58, -14.38) mm. It is noted that node 252946 generates anomalous peak values of 9.34×10^9 N in the Ty (longitudinal translation) DOF direction, corresponding to spatial coordinates of (17.51, -568.64, -12.92) mm, which may be related to the stress concentration effect caused by local geometrical mutation.

Table 4. Limit hydroproject

Value (N)	DOF	Node	x (mm)	y (mm)	z (mm)
5.84×10^5	Tz	254907	-14.77	-5531.58	-14.38
9.34×10^9	Ty	252946	17.51	-568.64	-12.92

The statistical distribution characteristics of translational DOF (as shown in **Table 5**) show that the constrained reaction range is mainly concentrated in the range of 10^8–10^{10} N, accounting for 99.97%, of which the range of 10^9–10^{10} N accounts for 67.03%, confirming the effectiveness of the system load transmission path. The cumulative proportion of the low-order interval of 10 is less than 0.03%, which indicates that the structural redundancy of the secondary bearing area is reasonable. This bimodal distribution feature is consistent with the evaluation criterion of load distribution of mechanical systems in ISO 148-1:2016 standard, which verifies the accuracy of boundary condition setting and condition simulation of the finite element model.

Table 5. Translational DOF distribution

Value	Percentage (%)
10^5–10^6	2.62×10^{-4}
10^6–10^7	2.62×10^{-4}
10^7–10^8	1.07×10^{-3}
10^8–10^9	32.97
10^9–10^{10}	67.03

The results of the static analysis (as shown in **Table 6**) show that the mechanical balance requirements of Newton's third law are met in all DOF directions. In the axial (Fx) and torque (Mz) two main bearing directions, the applied load has a good numerical correlation with the restraint reaction: when the force is 1.0×10^3 N applied in the Fx direction, the system reaction is -1.0×10^3 N, the residual magnitude is 3.89×10^{-6} N, and the relative error is controlled at 4.90×10^{-9} magnitude; The constraint reaction torque corresponding to the torque load 6.38×10^2 N·m in Mz direction is -6.38×10^2 N·m, the residual converges to 2.18×10^{-6} N·m, and the relative error is lower than 3.66×10^{-9}, which fully verifies the rationality of boundary condition setting of the calculation model.

The residual force convergence values of non-main bearing directions (Fy and Fz) are less than 3.50×10^{-7} N, and the relative error magnitude is maintained within the range of 10^{-10}–10^{-11}, meeting the residual convergence threshold requirements of ISO 10791-5 standard for static analysis of precision mechanical systems. For the bending moment component (Mx, My), the maximum residual moment is 1.96×10^{-9} N·m, and the numerical convergence index is better than the reference value of 1.0×10^{-6} N·m required by the engineering routine.

Table 6. Engineering report of static analysis

Components	Applied	Reaction force	Residual	Magnitude error
Fx (N)	1.0×10^3	-1.0×10^3	-3.89×10^{-6}	4.90×10^{-9}
Fy (N)	-5.67×10^{-8}	-2.87×10^{-7}	-3.43×10^{-7}	4.32×10^{-10}
Fz (N)	6.66×10^{-10}	4.10×10^{-8}	4.16×10^{-8}	5.24×10^{-11}
Mx (Nxm)	-5.55×10^{-10}	2.51×10^{-9}	1.96×10^{-9}	3.29×10^{-12}
My (Nxm)	-5.02×10^{-9}	1.37×10^{-8}	8.70×10^{-9}	1.46×10^{-11}
Mz (Nxm)	6.38×10^2	-6.38×10^2	-2.18×10^{-6}	3.66×10^{-9}

It is known from the finite element analysis engineering report that the relative amplitude error of each DOF direction is strictly controlled below 10^{-9} magnitude, and the convergence accuracy of 5.24×10^{-11} in Fz direction is very high. This data feature not only verifies the effectiveness of the mesh discretization scheme of the finite element model, but also verifies the rationality of the parameter setting of the iterative solver, providing reliable basic data support for the follow-up fatigue strength evaluation, evaluating the practicality of the parts designed by students, and verifying the realization of the objective of this practical course.

5. Effect evaluation and feedback

The establishment of the examination and evaluation system focuses on the comprehensive performance of students in multidisciplinary knowledge transfer, engineering problem modeling, innovation scheme design, unity and cooperation ability, etc., to ensure that the theoretical learning and practical application form a positive interaction loop. The evaluation of course setting includes collecting feedback from teachers and students, scientific evaluation of classroom effect and student performance by the teaching and research office, and further improvement and perfection of the course setting to make the practice course setting of automobile design more reasonable and effective.

5.1. Evaluation of students' practice results

In the last eight class hours, the teachers and students jointly accepted the team's achievements. The results were accepted by means of an on-site simulation demonstration and PPT defense, and scored according to the form of assessment and evaluation. The practice course not only paid attention to the results, but also paid attention to student participation, teacher-student interaction, simulation design, etc. See **Table 7** for the evaluation table.

Table 7. Assessment form

Evaluation Form			
Scoring item	**Total value**	**Marking criteria description**	**Score**
Student engagement	15	Attendance, task commitment, workload	
Quality of teacher-student interaction	10	How well questions are raised/answered, how often you take the initiative to speak in class	
Teamwork ability	10	Ability of division of labor and coordination within the group, contribution to the team	
Problem-solving ability	15	Project resolution analysis ability, ability to handle emergencies	
Innovative thinking	15	Project innovation, program originality, interdisciplinary application ability	
Outcome design	15	Technical integrity, project completion, analytical reporting standards	
Presentation defense	10	Expression logic, PPT presentation effect, question answer	
Other bonus points	10	As team leader, project reporting member, etc., can be increased or decreased as appropriate	
Total value	100		

5.2. Feedback on teaching design

The teaching situation of the course in the graduating class of the automobile application and maintenance specialty shows that the seven project teams can complete the project well and reply smoothly. The integrity of the project report is high, and the comprehensive score of each student can reach more than 80. From the students' feedback, more than 90% of the students agreed with the course form, thinking that "I can learn a lot of useful things during the project," "I need to learn computer software to complete this project, and I also master a skill after the project is completed." The teacher of the graduating class feedback that "during the course, through my participation in the whole process, I observed that the practice course can let students learn together in communication and cooperation, and the students realize the importance of cooperation, but also cultivate the students' ability of organization and coordination."

6. Conclusion

The automobile design teaching practice course is a new teaching design course based on project learning, supported by CATIA, a leading design software in the automobile industry, and taking "one center," "two dimensions," and "three levels" as the teaching concept. It shifts the teaching focus from the teacher center to the student center, and shifts the previous teaching method focusing on conclusions and light process to a more conclusions and heavy process. In the practical course, one or more types of automobile parts are selected for modeling, static analysis, and generation of engineering reports. Finally, the results are jointly evaluated by the teachers and students to achieve the objective of cultivating interdisciplinary, high-quality new engineering talents. Practical teaching is an important bridge for the transition of theoretical knowledge to actual production [10]. Through the results of this course design, we see the possibility of implementing practical education in higher vocational schools, promoting the transformation of the engineering education mode to project teaching in higher vocational schools, and avoiding the situation of students "studying books" [11]. In the modern society of industrialization, it is important for students to really master the skills required by enterprises and improve their ability to solve problems independently. The reform of comprehensive experimental teaching of engineering is a process with a long way to go and needs continuous exploration [12]. As a part of the vocational education industry, the future needs to further optimize the curriculum, expand the scope of curriculum implementation, and lay a solid foundation for cultivating high-quality engineering talents for social development and industry needs.

Disclosure statement

The authors declare no conflict of interest.

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