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Construction of integrated practice courses in mechanical engineering based on outcomes

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Abstract: Aiming to address the issue of the “isolated knowledge island” phenomenon caused by the traditional teaching system, leading to insufficient mechanical design ability in students, the integrated practice course “Comprehensive Design of Complex Mechatronic System” is constructed as a peak experience course based on real mechanical product cases. The ability-driven teaching method based on a four-module-collaborated immersive practice teaching scheme is presented to make students go through the entire project-based design process consisting of principle design, structural design, process design and electrical control design. The selection of project cases focuses on academic research hotspots and the states of art of scientific and technological development and fully takes into account the differences in knowledge mastery among different students. An outcome-oriented achievement evaluation method is also implemented to evaluate the students’ achievement from the integrated practice course according to the proposed teaching scheme. The construction of the integrated practice course can provide a useful reference for the continuous improvement of peak experience courses in mechanical engineering.

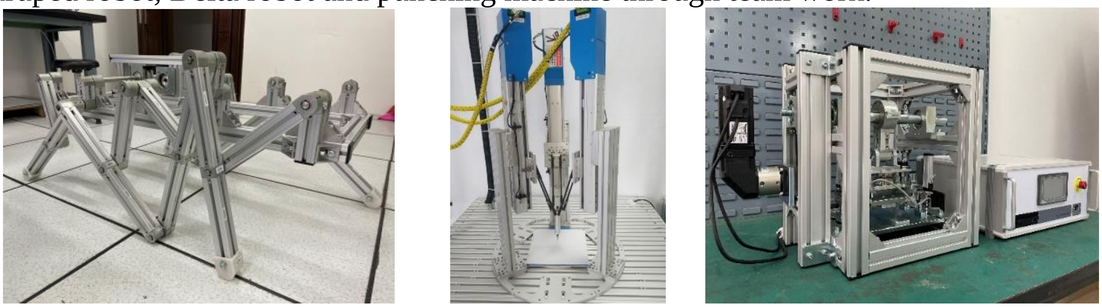
1. Introduction

In traditional teaching systems, various knowledge areas related to mechanical product design and manufacturing are taught in separate courses, each with its own teaching focus and objectives. Classroom teaching is conducted by the teacher for each course, and the content is taught in order. Similarly, engineering practice is trained course by course, and done in a specific order. However, this decentralized and independent teaching method, coupled with the lack of closely related training, makes it difficult for students to form a comprehensive and systematic understanding of mechanical product design and manufacturing from these isolated knowledge points. As a result, it is challenging for students to effectively transform their knowledge into practical design ability. Even if they have learned all the relevant courses, they may still lack a holistic understanding of design and lack the ability to apply it in practice [1]. Aiming to address the issue of the “isolated knowledge island” phenomenon caused by the traditional teaching system, leading to insufficient mechanical design ability in students, the integrated practice course “Comprehensive Design of Complex Mechatronic System” is constructed as a peak experience course based on real mechanical product cases and implemented in a way of project-based teaching [2]. Project-based teaching is to infiltrate the knowledge in the project in the teaching process so that students can feel the application of knowledge in the process of participating in the project, and also exercise the practical ability of students [3]. In this paper, the ability-driven teaching method based on a four-module-collaborated immersive practice teaching scheme and the outcome-oriented achievement evaluation method are proposed and applied in the construction of the integrated practice course.

2. Implementation of the integrated practice course construction

2.1. Ability-driven teaching method based on real engineering product cases

This course, “Comprehensive Design of Complex Mechatronic System”, dynamically adjusts and updates the engineering product cases of integrated practice for mechanical majors according to the academic research hotspots and the states of art in scientific and technological development. With the introduction and reference of the real reconfigurable modular equipment, students can participate in the whole project-based process of principle design, structural design, process design and electrical control design of the prototype of typical mechanical products shown in Figure 1 such as quadruped robot, Delta robot and punching machine through team work.

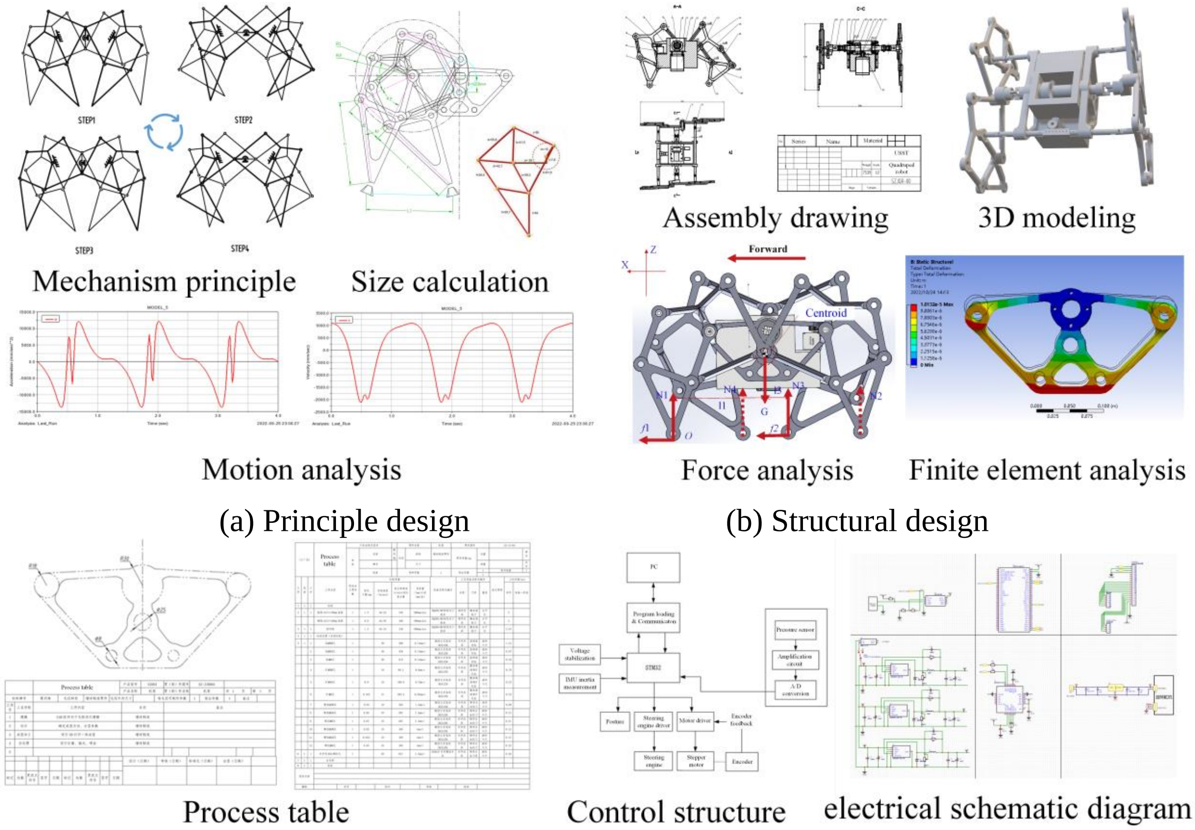


(a) Quadruped robot (b) Delta robot (c) Punching machine

Figure 1: Typical mechanical products based on reconfigurable modular equipment.

Through the four-module-collaborated immersive practice teaching, the course aims to connect and consolidate students' professional knowledge system. It cultivates their spirit of bold questioning and innovation, promotes the internalization of theoretical knowledge, and transforms it into outcomes thereby improving students' practical and innovative design abilities. By doing so, it effectively solves the "isolated knowledge island" phenomenon caused by traditional teaching modes, and facilitates interactive teaching that combines theory and practice.

Taking one of the quadruped robot product cases as an example, which is shown in Figure 2, students comprehensively applied the relevant knowledge from basic courses and professional courses to complete the principle design module including mechanism selection, size calculation, motion mechanism schematic drawing, and motion cycle drawing. The structural design module includes force analysis, 3D modelling, key parts checking, finite element simulation of the quadruped robot, and assembly drawing. The process design module requires the students to choose one of the main parts from the quadruped robot and formulate its processing process based on additive manufacturing. The electrical control system of the quadruped robot is designed and the motion control verification is finally completed during the electrical control design module.



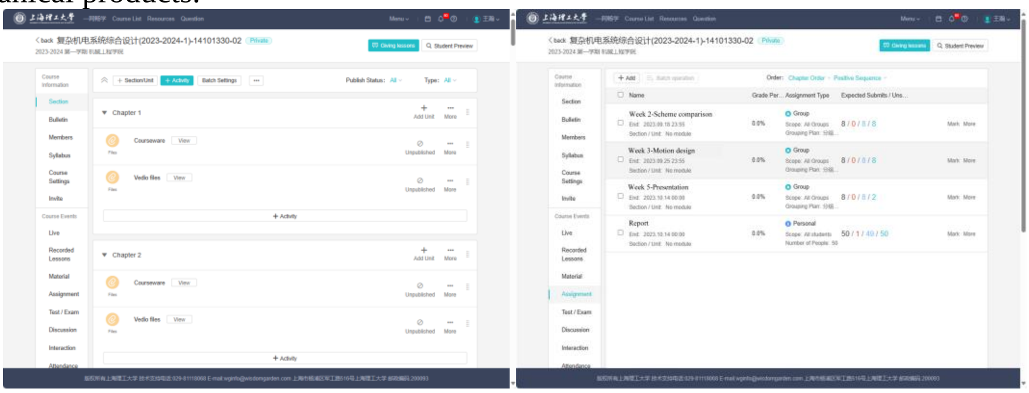
(a) Principle design (b) Structural design

(c) Process design (d) Electrical control design

Figure 2: Integrated practice case of the quadruped robot.

2.2. Outcome-oriented achievement evaluation method of the integrated practice course

This course relies on the online-offline teaching platform (Figure 3) linked by the classroom, laboratory and course website, which gives full play to the freedom advantages of online-offline mixed teaching. Through self-learning, Q&A, drawing, virtual simulation, physical assembly, electrical control practical operation, project presentation, and other aspects, the stage results of the case project are tested at the end of each teaching module so that the students' comprehensive practice ability achievement can be evaluated based on the outcome of each case project from the real mechanical products.



(a) Online website self-learning (b) Q&A process records

(c) Offline classroom presentation (d) Laboratory practice

Figure 3: Online-offline teaching platform.

During the construction of this integrated practice course, the achievement of course objectives is evaluated through two parts: the process evaluation and the testing evaluation, as shown in Table 1. The total score is calculated in a percentage system, with 60% for process evaluation and 40% for testing evaluation. The process evaluation includes 8 points for self-learning, which mainly examines the completion of knowledge learning on the course website, and 8 points for the Q&A, which mainly examines the rationality of the solution. The sustainability objective scores 8 points for energy conservation and environmental protection, mainly examining the students' consideration of energy conservation and environmental protection when designing mechanical products. The project management objective scores 8 points, which mainly examines the students' consideration of technical economics and decision making when designing products. The stage presentation scores 28 points, mainly examining the description of the design products at the end of the four modules. The testing evaluation involves drawing and report. By means of the characteristics of multi-dimensional evaluation content, diversified evaluation subjects, and diversified evaluation methods of the above evaluation method, the effect of the integrated practice course of mechanical majors on the cultivation of students' comprehensive design ability can be effectively improved.

Table 1: Evaluation of course objectives.

Objective	Evaluation item			
	Process evaluation		Testing evaluation	
	Item	Score	Item	Score
Analysis	Self-learning	8		
	Q&A	8		
Solution			Drawing & report	40
Sustainability	Energy conservation & environmental protection	8		
Team work	Stage presentation	28		
Project management	Technical economics & decision making	8		

3. Effect of the construction of integrated practice courses in mechanical engineering

The selection of project cases focuses on academic research hotspots and the states of art of scientific and technological development. The whole process of R&D of typical mechanical products such as quadruped robot, Delta robot, and punching machine is taken as the peak experience content of integrated practice courses for mechanical majors so that students can personally experience and put forward their technical solutions by using the classical theoretical knowledge they have learned when designing course project cases. In the process of solving a cutting-edge engineering problem, students can experience the sense of achievement of "learning is useful" and the sense of urgency of "learning is endless".

At the same time, the selection of project cases also fully takes into account the differences in knowledge mastery among different students. For students with weak foundation, the project case gives the "reference answer" of mechanical product design based on the existing reconfigurable modular equipment. Students can carry out the project design step by step with reference to the real equipment they can see and feel, and give full play to the advantages of the reconfigurable modular equipment, customize exclusive materials, and convert their own design scheme into actual mechanical products to complete the verification of the given function and technical requirement. This experience process pays attention to the exercise of engineering practice ability. For students with a solid foundation, the design of project cases is restricted only by functional and key technical requirements. It is not necessary to limit themselves to the idea of reconfigurable modular equipment. Students can mobilize their own innovative thinking, and create their own innovative designs by consulting relevant literature and referring to existing mechanisms or structural design solutions. This experience process emphasizes the cultivation of innovative design ability. All students can gain different benefits from the peak experience integrated practice course, forming their own knowledge, ability and value output.

4. Conclusions

Through the ability-driven teaching method and the outcome-oriented achievement evaluation method, the construction of integrated practice courses in mechanical engineering is implemented. The outcomes including the principle design of the mechanism, the engineering drawings of the mechanical product, process tables of key parts and control schemes of the mechatronic system prove that the integrated practice course is effective for the improvement of students' comprehensive design ability according to the real integrated practice case done by the students. The construction of the integrated practice course can provide a useful reference for the continuous improvement of peak experience courses in mechanical engineering.

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