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Research and Practice of AI+DBL Teaching Mode for Application Oriented Undergraduate under the Background of New Engineering

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Abstract: In view of the problems existing in the mechanical design course of Application-oriented Undergraduate under the background of new engineering construction, such as the single teaching method, the disconnection between theory and practice, and the lack of cultivation of students' innovation ability, this paper explores the application path of AI+DBL teaching mode with the deep integration of artificial intelligence technology and design based learning (DBL) in the mechanical design course. Guided by the training goal of application-oriented undergraduate mechanical talents, the ai+dbl teaching mode framework of "project topic selection task decomposition team cooperation process guidance achievement evaluation" is constructed, the supporting engineering case base and ideological and political case base are developed, and a multi-dimensional dynamic evaluation system covering four dimensions of knowledge mastery, practical ability, team cooperation and innovative thinking is established. Teaching practice shows that this mode can effectively promote the deep integration of mechanical design theory and engineering practice, significantly improve students' ability to solve complex engineering problems, teamwork spirit and innovative design thinking, and promote the transformation of teachers' teaching ideas and the improvement of teaching ability, providing a practical paradigm for the teaching reform of Mechanical courses in similar application-oriented undergraduate colleges.

Keywords: New Engineering; Applied Undergraduate; AI+DBL; Mechanical Design; Teaching Model.

1. Introduction

A new round of scientific and technological revolution and industrial change are accelerating the evolution. The new technology group represented by artificial intelligence and intelligent manufacturing is profoundly reshaping the talent demand structure in the engineering field. The Ministry of education actively promotes the construction of new engineering [1], clearly proposes to cultivate compound, innovative and applied engineering and technical talents, and requires colleges and universities to actively meet the needs of the industry and deepen the reform of engineering education [2-3]. As an important position for the cultivation of engineering and technical talents, the mechanical specialty of Application-oriented Universities undertakes the important mission of conveying front-line engineers and technical managers for the regional manufacturing industry [4].

Mechanical design is the core course of the major of mechanical design, manufacturing and automation, which is connected with the basic technical courses such as mechanical principle and engineering mechanics, and the practice links such as course design and graduation design. It has a pivotal position in the professional curriculum system [5]. This course not only requires students to master the design theory and calculation method of mechanical parts [6], but also emphasizes the cultivation of engineering design thinking and practical ability.

However, the traditional teaching of mechanical design course has been dominated by classroom teaching for a long time, with problems such as single teaching methods, disconnection between theory and practice, students' passive acceptance of knowledge, and insufficient training of innovative design ability [7]. Students can often pass the examination after completing the course, but it is difficult to complete a complete mechanical transmission device design task independently, which is significantly different from the ability requirements of Applied Engineering and technical talents under the background of new engineering [8]. The AI+DBL teaching mode formed by the deep integration of artificial intelligence technology and design based learning (DBL) is driven by real design projects, with the help of AI tools to help students find and solve problems in the design process, emphasizing that students are "learning by doing", which provides a feasible path to solve the above problems.

2. Research Status at Home and Abroad

2.1. Development Context of DBL Teaching Mode

Design based learning (DBL) originated from the practice of engineering education reform in the United States. Its core idea is to enable students to carry out inquiry learning around real design tasks [9] and actively build knowledge and develop ability in the process of completing design projects. Compared with problem-based learning (PBL), DBL emphasizes "design", the core link of engineering practice, and pays attention to the complete design thinking training of students from demand analysis, scheme conception, detailed design to optimization iteration, which is highly consistent with the essence of engineering education.

Foreign universities applied DBL mode to engineering courses teaching earlier. MIT and Stanford University have widely adopted the design project driven teaching method in

the introduction to engineering courses for junior students. Students establish engineering cognition by completing projects such as robot design and simple mechanical device manufacturing. In recent years, foreign educational circles have begun to explore the integration of AI auxiliary tools into the DBL teaching process, using intelligent tools to support students' scheme generation, design verification and performance simulation, and further improve the teaching efficiency of design projects.

2.2. Localization of Domestic DBL Teaching Mode

Domestic educators have carried out the Localization Practice of DBL mode in combination with the characteristics of different courses. Yang Cui of Henan Normal University proposed a DBL based network security course teaching mode [10] to solve the problem of how to stimulate students' interest and improve their independent inquiry ability in the network security course teaching, which effectively mobilized students' learning initiative by designing network security program projects. Liu Chang of Henan Institute of technology constructed the teaching model of product design course under DBL mode, integrating traditional culture and craftsman spirit into product design project training [11], realizing the organic combination of professional education and ideological and political education. Central South University of forestry and technology chenxingyan integrated DBL and flipped classroom theory and introduced furniture design course teaching [12], breaking the traditional mode of teachers' one-way indoctrination and students' passive acceptance, and building a relatively complete talent training system for furniture design.

2.3. Deficiencies of Existing Research

On the whole, some achievements have been made in the application of DBL teaching mode and the integration of artificial intelligence and education at home and abroad, but there are still two obvious shortcomings: first, the existing DBL practice is mostly concentrated in the professional fields of product design, furniture design, network security and so on, and the systematic research on the core professional courses of mechanical design, which are both theoretical and practical, is relatively scarce; Second, the research on the deep integration of AI technology and DBL teaching mode and its application in the mechanical courses of application-oriented undergraduate is still in its infancy, lacking an operable teaching mode framework and supporting resource system. In view of the above gap, this study takes the mechanical design course as the carrier to explore the construction path and practical effect of DBL teaching mode for Application-oriented Undergraduate under the background of new engineering.

3. Theoretical Connotation of DBL Teaching Mode and New Engineering Requirements

3.1. Core Features of DBL Teaching Mode

DBL teaching mode has three core characteristics. First, real project driven. DBL takes the design task close to the engineering practice as the learning carrier. What students face is not abstract exercises, but real design problems with clear functional requirements and constraints, which helps to stimulate students' learning drive. Second, design process orientation. DBL focuses not on the memory of a single knowledge point, but on the complete design thinking process. Students need to go through multiple stages, such as demand analysis, scheme conception, technical design, trial production verification, optimization and improvement, and gradually form the engineering design methodology. Third, iterative learning. Engineering design is essentially a process of repeated iteration and continuous optimization. DBL allows students to find problems and correct solutions in the process of project promotion, and deepen their understanding of knowledge in trial and error and reflection.

3.2. Ability Requirements of New Engineering for Applied Mechanical Talents

The construction of new engineering courses requires engineering education to shift from the direction of knowledge transfer to the direction of ability training, highlighting the cultivation of students' ability to solve complex engineering problems, innovative design ability, team cooperation ability and lifelong learning ability [10]. The mechanical graduates of application-oriented undergraduate are mainly oriented to the design department, process department and production line of equipment manufacturing enterprises, and need to undertake the practical tasks of mechanical product design, equipment technological transformation, production process optimization and so on [13]. This requires students not only to master the basic theory of mechanical design, but also to have the practical ability to apply the theory to specific engineering problems, as well as the communication ability to carry out collaborative design in the interdisciplinary environment.

3.3. Internal Fit between DBL and the Training Objectives of New Engineering Talents

There is a profound internal fit between the DBL teaching mode and the training objectives of new engineering talents. First of all, the real project attribute of DBL directly corresponds to the training requirements of engineering practice ability. Students need to comprehensively use the knowledge of multiple courses to solve practical problems in design projects, which is the training process of solving complex engineering problems. Secondly, the design process orientation of DBL is highly consistent with the cultivation of engineering innovative thinking. Students continue to break through existing ideas and form innovative design awareness in scheme comparison and optimization iteration. Thirdly, DBL is usually carried out in the form of team cooperation. Students need to work in teams, communicate and coordinate, which is completely consistent with the team cooperation ability training goal emphasized by the new engineering department. It can be said that the DBL teaching mode naturally conforms to the core concept of the new engineering construction, and is an effective starting point to promote the teaching reform of mechanical courses for application-oriented undergraduate.

4. Analysis on the Teaching Status and Adaptability of Mechanical Design Course for Application Oriented Undergraduate

4.1. Characteristics of Mechanical Design Course

The course of mechanical design has distinct disciplinary characteristics. First, the knowledge system is systematic. The course content takes the design of common mechanical parts (such as threaded connection, belt drive, gear drive, shaft, bearing, coupling, etc.) as the main line. There are independent design methods between each chapter, and they are interconnected through the overall design of the mechanical system, forming a complete knowledge network. Second, theory and practice are closely combined. The design and calculation methods in the course come from engineering practice and must return to engineering practice for inspection. Third, the design scheme has outstanding versatility. There are often many feasible schemes for the same mechanical transmission demand, which requires students to make a reasonable choice in the comparison of multiple schemes, which is in sharp contrast to the traditional exercise training method of "the only standard answer".

4.2. Main Problems of Traditional Teaching Mode

From the perspective of the teaching practice of mechanical design course for application-oriented undergraduate, the traditional teaching mode mainly has three problems [14]. First, the teaching method is mainly based on Teachers' teaching, students' passive acceptance of knowledge, insufficient classroom interaction, and it is difficult to fully mobilize their learning initiative. Second, theoretical teaching and practical training are separated. Curriculum design is often arranged after the end of the course. Students lack perceptual knowledge at the stage of learning theory, and they forget more about what they have learned when doing curriculum design. Third, the training of innovative design is weak. After class assignments are mostly repetitive design calculations. Students imitate examples to complete tasks and lack space for independent scheme conception and creative design.

4.3. Adaptability Analysis of DBL and Mechanical Design Course

The introduction of DBL teaching mode into mechanical design course has good adaptability. From the perspective of the corresponding relationship between knowledge modules, the chapters of belt drive design, gear drive design, shafting component design, etc. in the course can naturally be mapped into sub task links in design projects. From the perspective of ability training logic, the design and calculation ability, engineering drawing ability and scheme evaluation ability required by the mechanical design course are exactly the core abilities that need to be repeatedly applied and trained in the process of DBL project implementation. From the perspective of students' cognitive law, application-oriented undergraduate students are often better at understanding abstract theory in hands-on practice, and the DBL "learning by doing" model can better stimulate the learning potential of students at this level. Based on the above analysis, this study chose to systematically carry out the reform practice of DBL teaching mode in the course of mechanical design.

5. Construction of AI+DBL Teaching Mode

5.1. Overall Framework of Teaching Mode

The ai+dbl teaching mode constructed in this study takes "quality as the purpose, students as the main body, problems as the main line, ability as the core, evaluation as the means, and task driven as the way" as the basic idea [15], forming a five in one teaching process of "project topic selection task decomposition team formation process guidance result evaluation". In this framework, the real design project is the main line running through the whole teaching process. Students carry out autonomous learning and collaborative exploration around the project tasks in teams, and teachers change from traditional knowledge instructors to guides and resource providers in the learning process. As an auxiliary means, artificial intelligence tools are embedded in the whole teaching process to help students efficiently complete information retrieval, scheme comparison, design verification and other work at each stage of design, so as to improve learning efficiency.

5.2. Instructional Design Process

In the teaching design, this research systematically maps the knowledge points of mechanical design course with the design project link. At the beginning of the course, the teacher issued a comprehensive mechanical transmission device design project (such as the transmission system design of small belt conveyor), and divided the whole course into several sub task modules: the selection of transmission scheme corresponds to the belt transmission and gear transmission chapter, the shaft structure design corresponds to the shaft, bearing and coupling chapter, and the selection of connection mode corresponds to the threaded connection chapter. Each sub task module is promoted in accordance with the rhythm of "knowledge preparation - Design Practice - Discussion and comment". Students learn the corresponding theoretical knowledge synchronously in the process of completing the sub task, so as to realize the synchronous promotion of theory and practice. In terms of teaching schedule, the teaching hours of traditional theory will be reduced by about one third, and the spare time will be used for project discussion, scheme review and design guidance.

5.3. Development of Teaching Resources

The construction of supporting teaching resources is an important support for the effective implementation of AI+DBL teaching mode. This study focuses on the development of three types of resources. The first is the mechanical design engineering case library, which selects typical mechanical product design cases covering the main knowledge points of the course. Each case contains complete elements such as design requirements, scheme evolution process, key calculations, final drawings and design reflection, providing a reference model for students to carry out design projects. The second is the learning resources of 3D modeling and engineering drawing. Combined with the mainstream software such as SolidWorks, the teaching micro videos and operation guides such as part modeling, assembly design and engineering drawing generation are developed. The third is the course Ideological and political case library, which naturally integrates the ideological and political elements into

the design project discussion link by combining the engineering ethics and professionalism materials such as the heavy weapons of a large country and the craftsmen of a large country.

5.4. Integration Path of AI Tools

Artificial intelligence technology plays an auxiliary role in DBL teaching mode at three levels. In the problem discovery stage, AI tools can help students quickly retrieve design specifications, material performance data and standard parts information, reduce low-level repetitive work, and put more energy into scheme conception. In the scheme design stage, students can use AI to generate multiple alternative schemes and conduct comparative analysis to expand the design ideas. In the design verification stage, AI tools can help check common errors in the calculation process, prompt structural technological problems, and help students establish rigorous engineering design habits. It should be emphasized that AI tools are always auxiliary means rather than substitutes. Students must understand the engineering meaning of each design decision and cannot blindly rely on AI output results.

6. Multi Dimensional Dynamic Teaching Effect Evaluation System

6.1. Evaluation Dimension and Index Design

The traditional mechanical design course assessment is mainly based on the final examination results, which is difficult to comprehensively measure the comprehensive learning effect of students under the DBL mode. This study constructs an evaluation index system of four dimensions: first, the dimension of knowledge mastery, which tests students' understanding of the basic theory of mechanical design and design calculation methods through periodic tests, with a weight of about 30%; The second is the practical operation dimension, which measures students' practical ability by evaluating the quality of three-dimensional modeling, the standardization of engineering drawings and the accuracy of design and calculation, with a weight of about 30%; The third is the team cooperation dimension, which quantifies each student's contribution to the team through the combination of intra group mutual evaluation, team leader's evaluation and teacher's observation, with a weight of about 20%; The fourth is the dimension of innovative thinking, which evaluates students' performance in the aspects of scheme innovation, structural optimization and uniqueness of problem solving, with a weight of about 20%.

6.2. Combination of Process Evaluation and Summative Evaluation

In terms of evaluation methods, this study emphasizes the combination of process evaluation and summative evaluation. The process evaluation runs through the whole process of the project, including the review records of the scheme at each stage, the quality of the phased design results, and the participation in class discussion. The process score accounts for 60% of the total score. The summative evaluation is mainly reflected in the final design results (drawings, instructions) and the performance of the defense, accounting for 40% of the total score. This evaluation method effectively avoids the disadvantages of "one test determines the score", and guides students to pay attention to the usual design process rather than the final assault. At the same time, AI learning behavior analysis tool is introduced to record the data of students' resource access, discussion and participation on the learning platform, providing objective data support for process evaluation.

6.3. Quantitative Method of Team Contribution

Aiming at the phenomenon of "free riding" in team collaboration, this study designed a quantitative method of intra group contribution. After the completion of each project stage, the members of the group will score each other according to the difficulty, workload and completion quality of their respective tasks, and calculate the personal contribution coefficient based on the observation records of teachers on each student. The final team member's personal score=overall team score × personal contribution coefficient. This mechanism not only cultivates the students' sense of teamwork, but also ensures the fairness of the evaluation results. The experimental results show that this method effectively mobilizes the participation enthusiasm of each student, and the division of labor within the group is clear and the cooperation is smooth.

7. Conclusion

Facing the requirements of the new engineering construction for the cultivation of applied undergraduate mechanical talents, aiming at the prominent problems existing in the traditional teaching mode of mechanical design course, this paper systematically constructs the AI+DBL teaching mode framework, and verifies the effectiveness of this mode through teaching practice. The main conclusions are as follows: first, DBL teaching mode and mechanical design course have good knowledge adaptability and ability fit, which is an effective path to promote the teaching reform of core courses for application-oriented undergraduate; Second, the five in one teaching process of "project topic selection task decomposition team cooperation process guidance results evaluation" can effectively realize the deep integration of theoretical knowledge learning and engineering practice training; Third, a multi-dimensional dynamic evaluation system covering four dimensions of knowledge mastery, practical ability, teamwork and innovative thinking can more comprehensively and objectively measure students' comprehensive learning effectiveness.

Looking forward to the future, this study still has room for further deepening. First, with the rapid development of AI technology in the field of engineering design, it is necessary to continue to explore a deeper integration of AI tools and DBL teaching, and give full play to the supporting role of intelligent technology for personalized learning; Second, it can further expand interdisciplinary design projects, combine mechanical design with electronic technology, control technology and other contents, and better adapt to the demand for interdisciplinary talents in the field of intelligent manufacturing; Third, it is necessary to systematically evaluate the long-term impact of this mode on students' subsequent course learning and career development through a longer period of teaching tracking.

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