Creativity and Innovation
2025, VOL. 9, NO. 4, 217-220
DOI: 10.47297/wspciWSP2516-252748.20250904

Construction of Ability Output Oriented Evaluation System for Mechanical Design Smart Course

Xu Dan

Geely University of China, Chengdu, Sichuan, 641423, China

ABSTRACT
With the in-depth promotion of the made in China 2025 strategy, China's mechanical engineering field is undergoing an unprecedented technological paradigm transformation. The rapid development of emerging technologies such as intelligent manufacturing and digital twins has put forward new requirements for the ability structure of mechanical design talents. The traditional teaching mode of mechanical design based on knowledge transfer is difficult to meet the needs of the industry for high-quality talents with innovative thinking. This trend forces colleges and universities to reconstruct the curriculum evaluation system. Especially in the context of the deep integration of AI and other technologies with education and teaching, it is an inevitable choice to build an intelligent curriculum evaluation system to improve the quality of talent cultivation. Based on this, this paper carries out relevant research on the construction of the evaluation system of the intelligent course of mechanical design guided by the ability output, for reference.

KEYWORDS
Capacity output; Mechanical design; Wisdom course; Evaluation system

1 Introduction

At present, there are three prominent problems in the course evaluation system of mechanical design. The evaluation content focuses too much on theoretical knowledge and ignores the assessment of engineering practice ability; Single evaluation method; The subject of evaluation is mainly teachers, lacking the participation of industry enterprises. These problems lead to the disconnection between the curriculum evaluation and the real engineering scene, and it is difficult to accurately reflect the comprehensive ability level of students. With the popularity of the smart education platform, students' learning behavior data can be fully recorded. Therefore, exploring the ability output oriented smart course evaluation system can solve the inherent drawbacks of the traditional evaluation methods, promote the fundamental transformation of the teaching of mechanical design, and provide guarantee for cultivating innovative engineering talents to adapt to the era of intelligent manufacturing.

2 Analysis on the connotation of ability orientation of mechanical design course

2.1 Characteristics of ability oriented teaching concept

The ability oriented teaching concept takes students' measurable and verifiable practical ability as the core, breaks through the traditional teaching paradigm based on knowledge teaching, and emphasizes the deep transformation of "learning for application". The ability oriented concept is embodied in three characteristics in the course of mechanical design. One is the goal orientation. The industry demand standards are directly transformed into the training objectives of the course. For example, according to the framework of mechanical engineer ability standards, the specific indicators of students' mechanism design ability, material selection ability and so on are determined; The second is the dynamic process, which forms the ability development curve through real-time collection of students' operation data in the practice links such as CAD modeling and finite element analysis, rather than relying on a single final examination; The third is the multidimensional evaluation, which not only focuses on the achievement of hard technical indicators such as gear transmission design, but also evaluates the soft qualities such as students' communication leadership in project cooperation.

2.2 Classification of ability objectives of mechanical design course

The ability goal of mechanical design course can be divided into three dimensions: technology application layer, innovative design layer and engineering realization layer. The technology application layer focuses on the solidification of basic capabilities, including deterministic capabilities such as the implementation of mechanical drawing specifications and the selection and calculation of standard parts. These capabilities are often directly presented through quantitative indicators such as the operation proficiency of parametric design software and the national standard compliance rate of engineering drawings; The innovative design layer focuses on the ability to solve uncertain problems, such as the material

structure collaborative optimization design for lightweight needs, whose evaluation depends on the functional realization of the design scheme, and often adopts the evaluation method of combining expert blind evaluation with AI algorithm; As the highest level capability, the project implementation layer emphasizes the full chain transformation capability from drawings to physical objects, involving complex qualities such as cost control awareness and process feasibility judgment. Typical evaluation scenarios include the factory school joint defense of graduation design projects and the feasibility evaluation of mass production of discipline competition works.

2.3 The reverse guidance mechanism of ability orientation to curriculum content

The ability oriented reconstruction of the course content of mechanical design presents a significant reverse design feature. This guiding mechanism is first reflected in the dynamic adjustment of teaching modules. Secondly, in the iterative update of the case base, the traditional static cases based on gears and shafting have gradually given way to interdisciplinary comprehensive projects such as robot joint design, which naturally include modern mechanical system elements such as electromechanical integration and intelligent control, forcing the teaching content to move closer to the forefront of industrial technology; The deeper guidance takes place at the level of teaching logic. The course is no longer carried out according to the conventional context, but takes the typical product development process as the clue, organically embeds knowledge points such as material mechanics and tolerance fit into practice links such as demand analysis and conceptual design, and forms an immersive ability training ecology of "learning by using".

3 Construction of capacity output index system

3.1 Mechanical design core competency map

The map of mechanical design core competencies breaks through the limitations of the traditional disciplinary knowledge framework and constructs a three-dimensional capability coordinate system. In the vertical dimension, the basic ability layer includes the basic skills such as the standardized application of engineering drawing and the strength check of mechanical parts, which are directly reflected by the national standard compliance rate, calculation accuracy and other hard indicators; The advanced capability layer focuses on the innovation of system integration, such as the function matching design of Mechatronics devices, topology optimization of lightweight structures and other complex capabilities, and its evaluation often needs to be combined with the novelty of the design scheme for comprehensive judgment; The strategic ability at the highest level focuses on the design thinking of the whole life cycle of the project, which is reflected in the students' practice of sustainable development concepts such as the selection of environmentally friendly materials and the design of removable structures. In the horizontal dimension, technical ability, engineering management ability and innovative thinking ability are intertwined to form a networked ability matrix. For example, in a typical gearbox design project, students should not only show the accuracy of gear parameter calculation, but also prove their design ability of innovative lubrication scheme.

3.2 Quantifiable evaluation index design

The quantifiable evaluation index design based on the core competence map realizes the paradigm shift from fuzzy evaluation to accurate measurement. In the dimension of technology application, the parametric evaluation scale is used to quantify the design results at multiple scales. At the micro level, the standardization of the modeling is evaluated through the integrity analysis of the feature tree of the CAD model. At the meso level, the simulation reliability is evaluated according to the matching degree of the stress nephogram of the finite element analysis, and at the macro level, the ultimate test is carried out according to the functional realization degree of the physical prototype. The quantification of innovation ability is more challenging. By constructing an evaluation matrix containing three dimensions of novelty, practicability and economy, the innovation index of design scheme is calculated by using the patent database comparison algorithm. The evaluation of engineering practice ability relies on the project log analysis technology to generate the practice efficiency curve from 12 observation points, such as time management, resource allocation and risk plan.

3.3 Ability representation in smart environment

The intelligent teaching environment provides an unprecedented multi-dimensional data source for the representation of mechanical design ability. On the virtual simulation platform, each design iteration of students is completely recorded, including detailed data such as the modified trajectory, time-consuming distribution, reference call frequency, etc. These procedural evidences can reflect the maturity of design thinking more truly than the final results. The IOT experimental equipment captures the operation sequence of students in the process of physical assembly, and identifies the implementation of its process specification through motion capture technology, such as the accuracy of

bolt tightening sequence, the standardization of measuring tools, etc. For team collaboration soft skills, the intelligent collaboration system objectively quantifies students' leadership performance in the project through voice emotion recognition, text semantic analysis and other technologies. The most breakthrough is that all these discrete ability data are integrated into a dynamic ability model through digital twin technology, which can display students' current ability status in real time and predict their future development potential in specific fields based on historical data.

4 Evaluation system framework of intelligent course of mechanical design

4.1 Evaluation subject

The evaluation system of the intelligent course of mechanical design breaks the limitation of the traditional single evaluation of teachers, and constructs a multi collaborative evaluation subject network. Business mentors directly participate in the feasibility assessment of student project schemes through the online review platform, and their feedback focuses on the hard indicators from the industrial perspective such as production cost control and process realizability; The teachers in the school rely on the intelligent teaching system to track the students' 3D modeling iteration process, finite element analysis report and other digital learning traces in real time, forming a process ability growth file; The industry certification body conducts the third-party certification of students' professional ability by docking the course assessment data with the professional qualification standard of mechanical design engineer.

4.2 Evaluation method

The intelligent transformation gave birth to the paradigm revolution of the evaluation method of mechanical design course, forming a new data-driven evaluation mode. The embedded evaluation tool automatically captures the operation sequence of students in the design software, and identifies the rationality of the design logic through the behavior analysis algorithm, such as intelligent scoring of the standard query frequency and parameter modification trajectory in the process of threaded connector design; The virtual simulation experiment platform records the students' trial and error process in mechanism kinematics simulation, and uses reinforcement learning model to quantify the improvement curve of fault diagnosis ability; For the ability of innovative design, which is difficult to quantify, the hybrid reality technology is used to build an immersive evaluation environment. Experts can directly disassemble the students' gearbox design scheme in the virtual scene, and give interactive scores from the dimensions of meshing accuracy, lubrication layout and so on; The traditional written examination is transformed into a dynamic question bank system, which can intelligently push differentiated theoretical questions according to students' early practical performance, and realize the closed-loop verification of "practice theory".

4.3 Evaluation dimension

The evaluation dimension design based on the ability output orientation breaks through the fragmentation limitation of traditional curriculum assessment and forms a three-dimensional ability evaluation coordinate system. In the dimension of technical ability, 18 micro indicators such as the compliance of students' engineering drawings and the error rate of calculation instructions are directly extracted through the API interface of industrial software, and the standardized score is automatically generated in combination with ISO standards; The engineering literacy dimension focuses on evaluating students' performance of systematic thinking in the whole process of the project, such as analyzing the depth of "cost performance" trade-offs in their design schemes through text mining technology; The evaluation of non-technical ability relies on voice emotion recognition, log analysis of collaboration platform and other technologies to objectively present students' soft qualities such as leadership and communication efficiency in the team.

5 Build evaluation closed loop

5.1 Multidimensional feedback mechanism of evaluation results

The core of the closed-loop evaluation of smart courses is to establish an all-round feedback network of evaluation results. The system deconstructs the students' mechanical design ability into a dynamic three-dimensional radar chart through data visualization technology, and displays its corresponding position in the dimensions of structural design, process analysis and innovative thinking in real time. At the same time, it automatically pushes the reinforcement learning resources that match the weak links. If a student performs poorly in the shafting design score, the smart engine will immediately retrieve the previous excellent case videos and typical error analysis reports; In addition to presenting the review opinions of the enterprise tutor in the form of written comments, the design scene can also be reconstructed through virtual reality technology, so that students can intuitively understand the actual impact of professional

suggestions such as "unreasonable design of gearbox lubrication structure" in an immersive environment; The feedback data should be open to teaching managers at the same time to form the ability heat map from individual to class, and provide data support for curriculum reform.

5.2 Adjust the result oriented teaching strategy

In order to make the teaching strategy achieve a qualitative leap from experience driven to evidence driven by the in-depth mining of evaluation data, colleges and universities should adjust the structure of teaching objectives, optimize the proportion of teaching content, and reconstruct the design of classroom activities, such as strengthening the task driving of practice, improving the fit of case teaching, and increasing interactive and collaborative learning methods, so as to better match the pace of students' ability development. The smart teaching system should identify student groups with different ability characteristics through cluster analysis, automatically increase standard parts selection training for "strong innovation and weak specification" students, and customize 3D printing physical verification tasks for "precision computing and less practice" students; The dynamic adjustment of teaching content even extends to the teaching material level. Based on the "high-frequency and difficult knowledge map" generated by the evaluation big data over the years, the textbook compilers are promoted to upgrade the traditional secondary content such as "belt drive tensioner design" to thematic modules. For students with weak ability or slow progress, differentiated intervention can be implemented through hierarchical teaching, group mutual assistance, individual guidance after class and other ways to improve the precise supply ability of teaching resources. At the same time, teachers should also take the evaluation results as an important basis for curriculum iteration, regularly carry out collective analysis based on evaluation data in teaching reflection, and promote the systematic improvement of teaching strategies.

5.3 Build a capability growth tracking system

In the course of mechanical design, the ability growth should not only be reflected in the periodic performance evaluation, but also reflect the long-term accumulation of students' multidimensional abilities such as structural thinking, innovative consciousness, engineering expression, software application, etc. Colleges and universities can systematically record students' ability performance at each learning stage by introducing learning process data collection tools, project achievement file management platform and visual growth report system, forming a personalized ability growth curve, providing targeted teaching adjustment basis for teachers and clear ability development path for students. The system should realize cross course linkage and cross semester tracking, open up the ability correlation logic from professional basic courses to comprehensive design practice, and form the ability chain of vertical connection and horizontal integration. At the same time, the system should also have the intelligent analysis function to identify and intervene the abnormal waves of students' ability development, so as to truly promote teaching and learning through evaluation, and provide support for the closed-loop construction of the curriculum evaluation system.

6 Conclusion

Under the background of the current in-depth reform of engineering education, the innovation of the evaluation system of mechanical design course is related to the improvement of teaching quality, and also responds to the urgent demand of the industry for new mechanical talents. The rapid development of smart education technology provides a new possibility to solve the problem of traditional test paper evaluation, but it also brings new challenges. In short, the construction of smart curriculum evaluation system is not only the improvement of teaching methods, but also the practice of transforming engineering education paradigm from "what to teach" to "what to know", and its value will continue to appear with the deepening of the integration of industry and education.

References

[1] Qi Xianye Research on the application of smart education platform in Classroom Teaching -- Taking the basic course of mechanical design for vocational undergraduate as an example [J]. China management informatization, 2025 (4): 188-190.

[2] Zhang Yuemin, Wu xuefeng, Hao Xiaoru, et al Hybrid teaching reform and practice of mechanical design basis [J]. China modern education equipment, 2025 (1): 88-90.

[3] Wang Haizhu Teaching reform and practice of "Fundamentals of mechanical design" based on online and offline smart teaching [J]. computer procurement, 2022 (1): 102-103.

[4] Zhang Yi, Liu Hongbin, Qian Weiji, Zheng Yan Exploration on the ideological and political teaching mode of mechanical principle course under the background of new engineering [J]. China education technology equipment, 2022 (4): 91-93.