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Teaching Reform of the Course "Fundamentals of Mechanical Engineering Control" Based on the Theory of "Knowledge Visualization"

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Abstract: In recent years, with the proposal and implementation of the intelligent manufacturing strategy, mechanical engineering control theory has become the core support for the intelligent upgrading of equipment. However, as a core course for mechanical majors, "Fundamentals of Mechanical Engineering Control" features a strong theoretical and abstract nature. The traditional teaching mode easily leads to difficulties in students' understanding and insufficient learning interest. "Knowledge visualization" can present the abstract knowledge in the course in visual forms such as graphics, images, and animations, helping students better understand and master the course content, thereby fully stimulating their learning interest, improving their learning effects, and effectively cultivating their innovative and practical abilities. In this regard, this paper first expounds on the significance of the teaching reform of the course "Fundamentals of Mechanical Engineering Control" based on the theory of "Knowledge Visualization", and then proposes effective reform strategies, aiming to provide certain references for relevant researchers.

Keywords: Knowledge visualization; Fundamentals of mechanical engineering control; Teaching; Reform strategies

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1. Significance of teaching reform for the course "Fundamentals of Mechanical Engineering Control" based on the theory of "Knowledge Visualization"

1.1. Conducive to changing students' cognitive attitudes

The teaching reform based on the "knowledge visualization" theory can transform abstract knowledge into vivid graphics, images, animations and other forms. This enables students to contact and understand the course content more intuitively, no longer feeling that knowledge is out of reach. When students can clearly see the operation process of the control system and the interaction between various links through visualization, they will gradually shift from passively accepting knowledge to actively exploring it [1]. This change in cognitive attitude will stimulate students' learning enthusiasm and make them more willing to invest time and energy

in an in-depth study of the course content. In addition, this visual teaching method can also cultivate students' innovative thinking. When students can understand knowledge from a new perspective, they are more likely to find problems and put forward new ideas. In the process of observing visual models and animations, students may associate them with relevant phenomena in real life, thereby connecting theoretical knowledge with practical applications, which enables them to better adapt to the needs and changes of the industry [2].

1.2. Conducive to optimizing the presentation of course knowledge

Most traditional teaching models use texts and static pictures to teach knowledge, but it is difficult to comprehensively and intuitively present the complex knowledge points in the "Fundamentals of Mechanical Engineering Control" course to students. The "knowledge visualization" theory can transform complex and difficult-to-understand concepts and principles in the course into vivid visual models. For example, for the feedback link of the control system, the process of how the feedback signal changes the system output is drawn into an animation, allowing students to intuitively feel how the feedback principle works, thus breaking the dullness and incomprehensibility of textual narration in traditional teaching methods. In addition, knowledge visualization tools such as mind maps and concept maps can be used to sort out the knowledge points of the "Fundamentals of Mechanical Engineering Control" course. These visualization tools can help students clarify the connections and hierarchical structures between various knowledge points, assist them in building a more complete course framework, facilitate their understanding and memory of knowledge points, enable them to better accept and absorb knowledge points, and further enhance the teaching effectiveness of the "Fundamentals of Mechanical Engineering Control" course [3].

2. Teaching reform strategies for the course "Fundamentals of Mechanical Engineering Control" based on the "Knowledge Visualization" theory

2.1. Visual reconstruction of teaching content

(1) Systematically organize core knowledge

Teachers should sort out the key and difficult points in the course "Fundamentals of Mechanical Engineering Control", such as system composition, transfer functions, and time-domain analysis methods, and classify and arrange each knowledge point according to difficulty level, logical relationship, etc. At the same time, combined with the abstraction level and comprehension difficulty of the involved content, they should identify the course knowledge that needs visualization processing, to improve learning efficiency [4].

(2) Adopt appropriate methods to visualize different types of knowledge points

For example, for abstract course knowledge such as the principle of feedback control, using visual flowcharts and dynamic videos to describe it can not only intuitively show the information transmission path and feedback part, but also dynamically display the operation of the system, allowing students to more intuitively perceive the control effect. For complex concepts and principles like Laplace transformation and transfer functions, graphical methods can also be used for explanation. For instance, drawing function curves to reflect the impact of various parameters on system performance helps students understand their corresponding physical connotations [5].

(3) Realize visual teaching through real engineering cases

Teachers should select highly representative mechanical engineering cases based on the course content,

such as robot mobile control systems and CNC machine tool propulsion control systems, and visually present their working principles and structures through real-scene pictures, videos, 3D models, etc., enabling students to flexibly apply control systems in practical work and learn how to use the acquired principles to analyze and design such systems. In addition, teachers should guide students to combine theoretical knowledge with practical cases to enhance their problem-solving abilities [6].

2.2. Digital transformation of teaching methods

(1) Introduce virtual simulation experiments

Teachers should make full use of virtual simulation technology to build an experimental platform for mechanical engineering control systems, allowing students to operate personally on the platform, change the experimental environment and the structure of the experimental system, and observe the results of system motion responses without worrying about equipment damage in the experimental environment or cost issues. For example, when analyzing the stability of control systems, simulation experiments can be used to intuitively observe changes in system stability under different parameter conditions, understand the concept of stability and its influencing factors, thereby improving students' practical operation efficiency [7].

(2) Use online teaching tools to carry out blended teaching

Online teaching tools have resources such as online exams, courseware resources, and electronic textbooks. Teachers can upload the basic knowledge points of mechanical engineering control to online platforms, so that students can preview independently before class and master basic theoretical knowledge and skills. In offline classes, teachers focus on solving the problems encountered by students during self-study and conduct further analysis and discussion, thereby improving the efficiency and quality of classroom learning. In addition, online learning platforms can also record students' learning processes and data materials. Teachers conduct accurate analysis and evaluation of their learning processes based on relevant information, and propose targeted learning plans based on the analysis and evaluation results [8].

(3) Use artificial intelligence technology to realize intelligent tutoring

Artificial intelligence technology can provide intelligent tutoring and feedback based on students' learning situations and problems. For example, an intelligent tutoring system can understand the questions raised by students through natural language processing technology and provide accurate answers and guidance. In addition, artificial intelligence can also conduct real-time monitoring and evaluation of students' learning processes. When it finds that students have learning difficulties or lag behind in learning progress, it promptly reminds teachers and students and provides corresponding learning strategies and suggestions [9].

2.3. Diversification of knowledge visualization tools

To facilitate the orderly implementation of the "Fundamentals of Mechanical Engineering Control" course, teachers can introduce diversified knowledge visualization tools.

(1) Concept mapping tools

This visual learning tool can show students the logical relationships between different course topics, enabling them to clarify the course framework. When teaching complex course knowledge, teachers

can use concept maps to intuitively describe theorems, formulas, and application backgrounds in the knowledge, allowing students to visually perceive the logical relationships between knowledge points, thereby helping them understand and memorize course knowledge efficiently [10].

(2) Animation demonstration tools are also very effective

For dynamic processes in mechanical engineering control, such as system response and signal transmission, animations can present abstract theories vividly and intuitively. Students can more directly observe the operation of the system under different conditions, thereby better understanding control principles. Teachers can use professional animation production software or search for relevant high-quality animation resources online to serve teaching [11].

(3) Adopt virtual reality (VR) technology, augmented reality (AR) technology, etc.

This is to present the teaching process digitally and intelligently. Using VR technology, teachers can enable students to experience the operation of mechanical control systems without leaving the classroom, entering an immersive learning state. At the same time, it can also map virtual information to the real environment; for example, in the laboratory, students can use VR technology to access the operation guidelines and data information of physical objects, thereby improving the accuracy and convenience of operational practice [12].

2.4. Diversified innovation in assessment methods

(1) Appropriately increase the proportion of usual grades and experiment report scores

Regular assignments can help students consolidate the knowledge learned in class and cultivate their autonomous learning and problem-solving abilities. Teachers should create real-world scenarios to enable students to flexibly apply the knowledge they have mastered to solve problems. Experiment reports can test students' practical operation ability and understanding of basic experimental knowledge. At the end of the experiment, students are required to sort out and analyze experimental data and write experiment reports, including the experimental purpose, process, results, as well as their own experiences and reflections [13].

(2) Introduce project-based evaluation methods

Teachers can set up questions related to actual engineering projects and guide students to complete them in groups, including project planning, model construction, model simulation, etc. This is of great help in cultivating students' cooperative communication ability and engineering practice ability, and can also stimulate their innovative awareness. After the project is completed, the project is evaluated through group reports and defenses, and other groups and teachers are invited to evaluate the project and put forward questions, which can enhance teacher-student interaction and learning effects [14].

(3) Introduce online quizzes, which are more real-time and flexible

Teachers can arrange exam times according to teaching needs and obtain students' score information on time. Moreover, the exam content can be set as multiple-choice questions, fill-in-the-blank questions, short-answer questions, etc., to test students' mastery and understanding of knowledge from various angles. The online quiz platform can automatically calculate exam scores and issue analysis reports, enabling teachers to accurately grasp students' learning status. Evaluating students through the above diversified evaluation methods can make teaching evaluation more comprehensive and objective, thereby promoting the all-round development of students [15].

3. Conclusion

In summary, the teaching reform of the "Fundamentals of Mechanical Engineering Control" course based on the "knowledge visualization" theory is of far-reaching significance. This reform not only helps to change students' cognitive attitudes, enabling them to move from passive learning to active exploration, but also optimizes the way course knowledge is presented, breaking the limitations of traditional teaching, thereby comprehensively enhancing the effectiveness of course teaching. To this end, teachers can start with strategies such as the visual reconstruction of teaching content, the digital transformation of teaching methods, the diversification of knowledge visualization tools, and the diversified innovation of assessment methods, to cultivate more high-quality mechanical engineering professionals who meet the needs of the intelligent manufacturing era and inject strong impetus into the development of my country's mechanical engineering field. In the future, teachers should also be encouraged to carry out relevant teaching research and practical exploration, share teaching reform experience, form a good teaching reform atmosphere, and promote the improvement of the teaching quality of the entire mechanical engineering major.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Wei X, Liu X, Lai C, et al., 2024, Visualization Analysis of Application Status and Trends of Virtual Simulation Experimental Teaching Evaluation in Colleges and Universities: Based on CiteSpace Knowledge Graph Analysis. Computer Knowledge and Technology, 20(36): 158–160.

[2] Lu B, 2024, Exploration and Practice of Knowledge Visualization in Python Blended Teaching. Information System Engineering, 2024(09): 86–89.

[3] Song Z, 2024, Research on Construction and Visualization of Knowledge Graph for Computer Curriculum System in Colleges and Universities. Computer Knowledge and Technology, 20(23): 89–91 + 95.

[4] Liu J, Wu Z, Zhao F, 2024, Application of Knowledge Visualization Teaching Method in Courses of Geographic Information Science Major. Technology Wind, 2024(20): 118–120.

[5] Zhang Y, Di C, 2024, Knowledge Graph and Visualization Analysis of Teaching Reform in Financial Engineering Major Based on Citespace. Industrial & Science Tribune, 23(14): 59–62.

[6] Li X, 2024, Research on Visualization Teaching of Higher Mathematics Based on Innovative Ability Cultivation: Review on Theoretical Construction and Teaching Application of Visual Representation of Knowledge Visualization. Applied Chemical Industry, 53(07): 1755.

[7] Ma W, Mo X, Zheng G, et al., 2024, Analysis of Research Hotspots and Frontiers of TCM Professional Talent Training Based on Visual Knowledge Graph. Heilongjiang Science, 15(03): 50–53.

[8] Wu J, Liang Y, Fang J, 2023, Review on Education and Teaching Research of Higher Vocational Marketing Major Based on Visual Knowledge Graph. Vocational Technology, 22(08): 35–42.

[9] Li J, Liu B, Jiao A, 2023, Distribution of Research Hotspots and Evolution of Frontiers of College Teaching Management in China Since the New Century: Visual Knowledge Graph Analysis Based on CiteSpace. Heilongjiang Science, 14(11): 49–54 + 62.

[10] Wang L, 2022, Improvement Path of Knowledge Visualization Teaching for Fashion Design Major in Higher

Vocational Colleges. West Leather, 44(14): 83–85.

[11] Liang Z, 2022, Knowledge Visualization Theory and Its Teaching Application in Higher Vocational Logistics Major. Logistics Technology, 41(06): 153–156 + 160.

[12] Yan Y, Ren Z, Wang J, 2019, Application of Knowledge Visualization Method in the Teaching of Fundamentals of Mechanical Design. Journal of Yuncheng University, 37(03): 85–88.

[13] Yan Y, Li X, 2019, Research on Application Mode and Practice of Knowledge Visualization in Mechanical Major Teaching. Times Agricultural Machinery, 46(06): 111–112.

[14] Wang H, 2019, Research on Application Mode of Knowledge Visualization in Mechanical Major Teaching. Hubei Agricultural Mechanization, 2019(10): 67.

[15] Yang Z, 2018, Research on Application Mode and Practice of Knowledge Visualization in Mechanical Major Teaching. Vocational Technology, 17(08): 59–62.