



Practice and discussion on digital teaching of polymer physics under the background of “double carbon”

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Abstract. "Polymer Physics" is one of the most important required courses in polymer materials. It has the characteristics of deep theoretical level, many abstract concepts and strong logic. Students' understanding and knowledge of the course need to be improved. Based on classroom wisdom, the construction of the digital transformation of high polymer physics course, guided by the "double carbon" goal, around the central idea, the structure and the properties of the course content, the comprehensive construction of digital resources, the interactive, hybrid teaching mode, comprehensively improve the efficiency of course, the knowledge module, and introduce a large number of teaching cases and ideological points, innovation appraisal method, strengthen the learning process, It stimulates students' enthusiasm for learning, realizes the student-centered, improves the teaching effect, and thus cultivates applied talents with both ability and morality in the field of polymer materials.

Keywords: PolymerPhysics; Digital Transformation; “double carbon”; Multi-level Question Bank; Classroom Testing; Blended Teaching Method

1 Introduction

The 14th Five-Year Plan for National Economic and Social Development and the Long-Range Objectives Through the Year 2035, issued in 2021, emphasizes the goals and tasks of digital economic and social development. Education is the foundation of the country, the source and power of social and economic development. The development of education in the future is bound to keep pace with the times and form an innovative system of digital education, In the face of the rapid development of the international social situation and economic market structure^[1]. Online teaching forms such as blended learning and immersive online interactive classroom teaching are important development trends in teaching reform in universities^[2-3].

In 2020, when the COVID-19 broke out, the Ministry of Education issued a notice of suspension of classes without suspension, which made China's online education grow by leaps and bounds, and also made teachers, students and teaching assistants quickly adapt to the online teaching mode, which greatly improved the information resources and information technology application ability^[4-6]. Promote high-quality training of professionals related to "dual carbon"^[11]. Obviously, in order to achieve the

grand goal of "dual carbon", the research and application of polymer materials, as well as the cultivation of "dual carbon" talents in the field of polymer engineering, have become crucial factors for social development^[12]. Faced with the transformation of the domestic and international environment, the course of Polymer Physics has undergone a breakthrough transformation^[13-15].

Polymer Physics is the most important compulsory course^[1] among the courses related to polymer materials. It studies the relationship between polymer structure, performance and application. In the field of applying polymer materials, it is necessary to master the knowledge points of polymer physics. Therefore, polymer physics is a basic compulsory course for the majors related to materials, fine chemical engineering, applied chemistry, biopharmaceuticals, etc. Only by mastering polymer physics can we better design the structure of new polymer materials, enabling them to have ideal performance, meet the needs of carbon neutrality and carbon peaking, and make polymer materials more widely and reasonably applicable. Based on this, polymer physics courses have also undergone a digital teaching transformation in this transformation, comprehensively constructing online resources and presenting a multi-dimensional and multi-level hybrid teaching model to meet the needs of sustainable ecological development in higher education^[7-10]. The Digital transformation of polymer physics course has been comprehensively constructed from the following aspects:

2 Utilizing the school's online platform, comprehensively build online resources to meet students' needs for preview, learning, and review

(1) Establishing a knowledge thinking map and introducing teaching methods through case studies;

(2) Establish knowledge point module micro videos to form a mixed online and offline teaching mode;

(3) Establish animation resources for polymer microstructure, vividly depicting the micro world and molecular motion, making abstract knowledge that is difficult to express and understand intuitive and easy to understand;

(4) Establish performance testing videos to verify the learning thread that polymer structure determines performance, so that students can form the concept of applying what they have learned;

(5) Establish multi-level online question bank resources, practice comprehensively in and out of class, and deeply grasp key knowledge points;

(6) Establish cutting-edge technology modules for polymer materials, collect new materials, latest developments in new technologies, implement the concept of sustainable development, and cultivate "dual carbon" engineering talents.

(7) Introduce famous teacher teaching videos and fully utilize network resources;

3 Comprehensively improve classroom teaching efficiency and adopt interactive teaching

- (1) Design classroom interactions and Q&A to test students' knowledge mastery;
- (2) Smart classroom teaching combined with blackboard writing, fully utilizing digital resources;
- (3) Classroom quizzes and analysis to consolidate key knowledge points;
- (4) Group discussion, analysis, summary, and analysis of the role of relevant knowledge in practical applications.

4 Comprehensive ideological and political education to cultivate new materials with correct perspectives

(1) Through the rise of Chinese materials under the COVID-19, stimulate students' patriotic feelings and establish a correct world outlook; Although science knows no borders, scientists have their homeland. When explaining the history of polymer development, the starry masters' perseverance and spirit in polymer material research during the New China era inspire a new generation of young people, stimulate students' national pride, and establish a correct worldview.

(2) By analyzing the structure of polymer materials, guide students to establish a correct outlook on life; A medical mask that is essential for everyone, consisting of three layers, all of which are made of polypropylene but have completely different functions. The outer layer is water resistant, the middle layer is the core filter layer, and the inner layer is moisture absorbing. At the same time, polypropylene can be made into packaging boxes, shampoo bottles, and so on. Why do they all have different functions when they are made of polypropylene? Different preparation methods result in different condensed structures of polypropylene materials, leading to differences in their performance in use. Internal unity makes it difficult for external enemies to enter, just like interpersonal relationships, guiding students to establish a correct outlook on life.

(3) Establishing correct values through the application of polymer materials. Polyethylene materials can be used to make both ordinary cling film materials and expensive artificial bone medical materials, inspiring students to combine their own characteristics and create their own characteristics. Naturally, we are useful and establish correct values.

5 Comprehensive innovation assessment mode:

Online+offline comprehensive assessment mode, that is, total score=attendance+video learning+discussion+homework+online testing+final assessment, emphasizing the learning process and efficiency.

Guided by the concept of digital teaching, the polymer physics course has established a comprehensive digital teaching model of "**guide-lecture-Learning-practice-**

examine-research", which stimulates students to quickly grasp the key points of knowledge and apply what they have learned. The specific plan is as follows:

Guide: Mind mapping+case introduction teaching. (1) The polymer physics course has established a knowledge point thinking map by sorting out the entire book content, which is divided into course thinking maps and chapter knowledge point thinking maps to improve students' overall awareness and quickly grasp the key points of the course knowledge.

Case 1: The course mind map enables students to quickly grasp the key points of knowledge, have a global awareness, and verify the points in the mind map one by one in the classroom, giving students a sense of achievement and improving classroom efficiency.

(2) Case introduction teaching: design and collect teaching cases according to the knowledge points in the chapter. Polymer physics studies the relationship between molecular structure, performance and molecular motion. Why study the structure of polymers? What's the use of it- Problem import:

Case 2: Announce a group of data: after the outbreak of COVID-19 in 2020, more than 15 million masks are urgently produced in China one day, made of melt blown polypropylene; In 10 days, a Huoshenshan Hospital was built, which was made of more than 30000 square meters of high density polyethylene anti-seepage membrane, box type plank houses and other polymer composites. From March to May 2020 alone, China exported epidemic prevention materials to 200 countries and regions, including 70.6 billion masks, 340 million sets of protective clothing, 115 million goggles, and so on. Why is China's speed so shocking the world? Let's take a look at the development of materials in China. Therefore, exploring the structure and performance of polymer materials will contribute to social development and human progress, and is also the foundation of a strong country. This will stimulate students' sense of mission in learning polymer physics!

Studying the chain structure of polymers, as well as the stacking of individual molecular chains and inter molecular chains, involves a microscopic world that cannot be seen or touched. Traditional teaching methods are difficult to leave a deep impression on students and can only rely on their gradual understanding. Through case teaching, students can fully understand the close relationship between microstructure and macroscopic performance.

Case 3: Playing video materials, conducting heat resistance experiments on polystyrene plastic. A sample of polystyrene plastic with a similar appearance, one type becomes soft when placed in boiling water, while the other type remains unchanged when placed in boiling water; Why? The vast majority of students' answers are about the production process. At this point, the teacher talked about the structure of polymer chains again. When it came to the impact of polymer configuration on performance, the students suddenly realized that the crystalline structure of identical polystyrene is resistant to boiling water, while the amorphous structure of random polystyrene has a softening point of over 80 degrees and is not resistant to boiling water. Exploring the essence of knowledge with questions has improved students' exploration of science.

Lecture: The whole process of classroom teaching is videotaped and edited into micro videos of each knowledge point module. Online resources are established, so that

students can watch the course playback as review, or watch in advance for preview, or choose to review the micro videos of knowledge points for confusion, regardless of time and venue restrictions, so that the Flipped classroom model can play a role. At the same time, we will use the school's online platform to introduce renowned teachers' teaching videos (such as the introduction of national first-class polymer physics course videos on the Learning Platform), break the university wall, balance educational resources, and create comprehensive student learning resources. For abstract concepts, we will use animation to present them, allowing students to vividly learn the chain structure and molecular motion of polymers. According to statistics, students have the highest viewing rate of videos and animations on modular knowledge points.

Case 4: Chapter 5, The Amorphous State of Polymers. There are many knowledge points in the chapter, so six micro videos are produced: ① the mechanical three states of amorphous polymers and their corresponding molecular motion; ② Glass transition theory; ③ Factors affecting glass and transition temperature and methods for improving heat resistance; ④ Analysis of Polymer Viscous Flow Characteristics; ⑤ Analysis of factors affecting viscous flow temperature and viscosity; ⑥ The orientation state and application of polymers. Students can selectively carry out review activities based on vague points in the classroom, greatly saving time and conducting learning activities efficiently.

Case 5: Chapter 2, Chain Structure of Polymers. Polymer chains possess flexibility due to internal rotation. When taught by teachers, students' understanding can only be limited to imagination. However, in the form of animation, polymer chains rotate around carbon carbon single bonds, resulting in the entire polymer chain presenting countless conformations in space and possessing flexibility. Students intuitively understand the molecular motion form of polymer chains, I have gained a profound understanding of the different properties generated by molecular motion. Similarly, the isotactic configuration of polymer chains, the dissolution process of polymers, i.e. the mixing process between polymer chains and solvents, the melting process of polymers, the crystallization process of polymers, the stretching process of polymers, and other relaxation phenomena corresponding to the molecular motion of polymer chains are collected and organized into animation resources, so that students can learn at any time and deepen their understanding of abstract theory.

Learning: student-centered, including classroom learning, video learning (pre-view+review), and discussion (online+offline). The best way to learn is to listen carefully to the class. Based on the extensive and in-depth knowledge learned in university, students may not be able to digest all classroom knowledge. Therefore, multi-level teaching video resources have been established to urge students to study diligently and improve learning efficiency.

Case 6: After studying the crystalline state of polymers in the polymer physics course, online discussions will be conducted to compare the internal connections and differences among several factors: factors that affect the flexibility of polymer chains, factors that affect the glass transition temperature, factors that affect the viscous flow temperature, factors that affect the viscosity of polymer melts, and factors that affect the melting point. In the traditional teaching mode, the accuracy rate of Multiple choice questions for several factors is about 60%. After online discussion and teachers'

classroom supplementation, students understand that the essence of several factors is the difficulty of molecular movement. As long as the problem is analyzed from the perspective of molecular movement, it will be solved. For example, the factors that affect the glass transition temperature are the factors that affect the movement of chain segments. Factors that aid in chain segment movement, such as low glass transition temperature, and factors that hinder chain segment movement, result in high glass transition temperature. Improve the accuracy of answering questions to over 90%.

Practice: Online and offline exercise detection and practice, establish a multi-level test bank, including classroom quizzes for knowledge points, chapter tests for each chapter, randomly generated simulation tests for students to practice before the exam, and consolidate key knowledge in the form of assignments. Through repeated training, students' grades have significantly improved. After conducting a survey of students, it was found that the training and analysis of classroom quizzes can timely consolidate knowledge and deepen students' cognition, which has been widely recognized by students.

Case 7: Learn the chapter of polymer solution, focusing on the Entropy of mixing, Gibbs free energy of mixing, huggins parameters, second virial coefficient, excess Chemical potential of polymer solution, 10 Multiple choice were designed for temperature, and a 5-minute class quiz was given and analyzed in time, so that students no longer feel obscure about thermodynamic functions, and problems related to thermodynamic functions can be well used in subsequent classroom teaching.

Examine: Innovate the examine mode and conduct a comprehensive assessment, with a total score of 40% for daily performance and 60% for exam performance. Daily grades include attendance and video learning, accounting for 10%; Homework, accounting for 10%; Classroom interaction+discussion accounts for 10%; Online testing accounts for 10%; The Final examination score accounts for 60%. Comprehensive assessment ensures that every effort made by students is recorded, avoiding the one-sidedness of the final exam, and constantly monitoring students' learning status, providing timely supplementary guidance, comprehensively promoting the improvement of students' academic performance.

Research: By studying material properties and testing experimental reflection theory, students can intuitively experience the impact of polymer microstructure on macroscopic properties, and learn to summarize and analyze - what is learned is what is used. Through the participation of cutting-edge technology modules and research projects in polymer materials, we aim to enhance students' exploration of polymer materials, continuously pursue new materials and technologies, and maintain an innovative spirit.

Case 8: Play the test video of polymer Strength of materials performance, intuitively show the test process, analyze the process, and draw the polymer tensile curve, so that students can truly understand the strength of the material, analyze the process of ordinary elastic deformation, strain softening, forced high elastic deformation, strain hardening, fracture, etc., distinguish the difference between brittle fracture and ductile fracture, and analyze the tensile process from the perspective of molecular motion, Summarize the measures for material reinforcement.

Case 9: Play a video on making photoresist, introduce Huawei's main technologies, and let students understand the principles of photoresist in chip manufacturing technology, learn the basic knowledge and key technical points of polymers in photoresist, understand the development of domestic and foreign photoresists, sow a seed of innovation in students' hearts, guide students to work hard in specialized research, actively participate in university student innovation and entrepreneurship projects and teacher research projects, and achieve the rejuvenation of the country through technology.

Case 10: The 14th Five Year Plan has put forward higher requirements for new materials. New energy materials, environmentally friendly materials, help to achieve energy conservation and emission reduction, meet the needs of green, low-carbon, and sustainable development. So how to design new material structures to meet the goal of "dual carbon"? By introducing the case of "corn plastic" and analyzing the structure of polylactic acid, the mechanism of biodegradation, and the methods of co polymerization to regulate degradation rate, the central idea of structure determining performance in polymer physics has been once again confirmed. This has strengthened students' confidence in learning basic knowledge and expanded their understanding of new materials, laying the foundation for cultivating innovative "dual carbon" talents.

6 Conclusions

Through the Digital transformation construction of the course of Polymer Physics, the efficiency of students' participation in the classroom has increased significantly, the participation in online tests and discussions has reached 100%, and the exam scores have also been comprehensively improved. At the same time, it has stimulated students' love for their motherland and polymer materials. During the course learning process, students make full use of digital resources, are attracted by advanced materials, and gradually learn to think deeply, analyze problems, and solve problems, thus becoming a "dual carbon" composite talent with both moral and talent in the field of material engineering in the new era.

Acknowledgments

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