Journal of Education and Educational Research
ISSN: 2957-9465 | Vol. 9, No. 1, 2024

Research on Flipped Classroom Based on the Course of Polymer Modification

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Abstract: How to improve students' self-learning ability and cultivate their ability to solve complex engineering problems during the teaching process is a challenge to undergraduate course teaching. This study focuses on the teaching of "Polymer Modification" for third year students majoring in Polymer Materials and Engineering at the School of Materials Science and Engineering, North China University of Technology. The shortcomings of the original teaching methods were systematically analyzed, and a teaching model of "BOPPPS+flipped classroom" was constructed. The teaching content was reconstructed, and the specific process and operational effects of the new teaching model were systematically discussed. This study provides ideas and references for the teaching reform of courses related to polymer materials and engineering.

Keywords: Self-learning Ability; BOPPPS; Flipped Classroom; Teaching Reform.

1. Introduction

"Polymer Modification" is a course with typical interdisciplinary characteristics in the field of polymer materials and engineering. It is highly theoretical, has a wide range of knowledge, and is closely related to engineering applications. It integrates multiple basic courses in the field of polymer materials and engineering; The course content can be used for product research and development, process design, production management, quality testing, scientific research, etc. in the fields of plastic, rubber, composite material processing, modification, and application. The Chinese Ministry of Education has issued the "Implementation Opinions on the Construction of First Class Undergraduate Courses", which requires improving the "high-level, innovative, and challenging" nature of the curriculum, namely "gender equality", focusing on creating "golden courses", and comprehensively improving the quality of talent cultivation. How to improve students' self-directed learning ability and extract complex engineering problems related to polymer materials and integrate them into teaching are challenges to the teaching work of this course, as well as opportunities for teaching reform. In response to the problems existing in traditional teaching of this course, the author has explored and practiced a teaching model using "Learning Pass" as the carrier and "BOPPPS+flipped classroom" as the means of implementing the teaching process, and has achieved good teaching results. The so-called BOPPPS teaching refers to the abbreviation of six teaching stages and methods, which are course introduction Bridge, learning objective, pre assessment before class, participatory learning, post assessment after class, and summary. Flipped classroom refers to students using videos before class MOOC 、 Electronic books and other resources are used for self-directed learning, while the classroom has become a place for interaction between teachers and students, as well as between students and students, including answering questions and applying knowledge. The traditional teaching mode of teachers giving lectures as the main focus and students passively receiving knowledge has been flipped into a self-study mode where students learn independently and teachers intervene as a supplement, thereby mobilizing students' enthusiasm and obtaining a deeper level of knowledge understanding. This study has distinct disciplinary characteristics and practical significance, which is beneficial for providing reference for the teaching reform of related courses.

2. The problems faced by the original teaching mode

In recent years, guided by the principles of "solid foundation, broad scope, strong ability, and high quality", the teaching of courses has replaced "knowledge transmission" with "student ability cultivation" as the goal, and the cultivation of ability is reflected in cultivating students' ability to solve complex engineering problems. The contradiction between limited class hours and constantly increasing content is becoming increasingly prominent. Although multiple teaching methods have been integrated into the teaching process, there are still some shortcomings.

(1) Focusing mainly on imparting knowledge has failed to effectively highlight the subject status of students.

(2) There are few comprehensive engineering application cases. Causing students to be unable to establish internal connections between knowledge points, unable to understand the learned knowledge from point to surface, and many professional issues are difficult to connect with practical engineering.

(3) The development of personalized education is not deep enough. The original teaching mode is influenced by factors such as class hours, time, and location, which is not conducive to students' in-depth learning.

(4) Lack of a systematic evaluation mechanism that runs through the entire process. The original assessment and evaluation methods ignored the assessment of student autonomy and innovation.

In response to the above issues, it is necessary to improve and integrate the teaching content of this course, and continuously update teaching methods and improve evaluation mechanisms in teaching.

3. Improvement of teaching methods

The manuscript should include a conclusion. In this section, summarize what was described in your paper. Future directions may also be included in this section. Authors are strongly encouraged not to reference multiple figures or tables in the conclusion; these should be referenced in the body of the paper.

3.1. Current situation of educational reform supported by "Internet plus"

In the context of the construction of "new engineering", ability cultivation has become an important driver for the promotion of the connotation of many colleges and universities. Teachers need to investigate all aspects of students' "pre class in class after class" learning, assess students' cognitive process and practical application ability, give students feedback or make teaching adjustments in time, which can be conducive to the cultivation of students' innovation awareness and practical ability. The development of Internet technology has broken the space-time constraints of knowledge acquisition, making knowledge more open and diversified, and providing technical support for teachers to observe, track and supervise students' learning throughout the process.

Under the support of "Internet plus" technology, there can be multiple learning modes and different learning platforms. With the integration of science and education as the core, the "Internet plus" technology is adopted to integrate information technology into the teaching process. A communication bridge is built between pre class preview and classroom teaching, which enhances the real-time and interactive nature of the curriculum, realizes the transformation of the teaching mode from "teaching centered" to "research and learning centered", improves the enthusiasm and learning quality of students, and realizes classroom interaction online forever, achieving good teaching results.

3.2. Design of "BOPPPS+Flipped Classroom" Teaching Mode for Polymer Modification Course

BOPPPS+flipped classroom is an organic combination of classroom teaching and online teaching. Before class, online resources and engineering cases are fully utilized to achieve pre class learning, and then discussions, collaboration, and personalized guidance are conducted in classroom teaching to achieve flipping of traditional classrooms. For the course of Polymer Modification, we propose a teaching model guided by "ability cultivation" and establishing a "BOPPPS+flipped classroom". We explore a new teaching and education model that integrates "learning communication classroom teaching complex engineering cases flipped classroom whole process evaluation" suitable for talent cultivation in "new engineering". The teaching of "BOPPPS+Flipped Classroom" based on the Learning Platform mainly includes six parts:

(1) Study preview. Make full use of the Learning Platform for pre class preview, and place learning materials highly relevant to the course content on the Learning Platform's modules such as notifications, activities, materials, and problem discussions., Realize students' autonomous learning and discussion of learning resources, allowing for real-time interaction between teachers and students, breaking the limitations of time and space, providing assistance to students who have not mastered basic knowledge, elevating students with solid foundations, and achieving personalized education.

(2) Consolidate course objectives

By previewing, students can have a clear understanding of the key and difficult points of the course, and condense the specific teaching objectives and ability requirements of this course.

(3) Pre class survey

By using modules such as the Study Platform Problem Discussion, we aim to assess students' mastery of basic concepts, principles, and other aspects of the upcoming course, in order to fully grasp their learning status.

(4) Classroom teaching focuses on lecture sharing and in-depth student participation in discussions. The classroom time is divided into two parts: concentrated time for intensive lectures, leveraging the advantages of traditional teaching methods, interpreting key and difficult parts, and teachers leading this part of the time to ensure systematic and advanced learning. During other times, utilizing functions such as class screen mirroring, interactive communication, in class testing, and thematic discussions, students are guided to analyze and discuss challenging content such as engineering cases, effectively igniting their interest points, improving their ability to analyze and solve problems, and enhancing the challenge of the course.

(5) After class quiz

Utilize modules such as homework and knowledge tests on the Learning Platform to assess students' mastery and application of knowledge.

(6) Summary and evaluation

Using online data from the Learning Platform and combining it with student classroom performance, evaluate the entire process of teaching and learning. Conduct a full process assessment of teaching and learning before, during, and after class. Summarize and analyze the various learning data of the implementation class, in order to identify problems, summarize patterns, and provide experience and methods for future teaching.

3.3. Reconstructing the Teaching Content of Polymer Modification

This study focuses on the teaching of "Polymer Modification" for junior students majoring in Polymer Materials and Engineering at the School of Materials Science and Engineering, North China University of Science and Technology. Based on the self-designed textbook by the author's team, the teaching content is restructured with "theory performance application" as the main theme. The aim is for students to master the thermodynamic principles of polymer blending modification, understand the relationship between polymer blending phase morphology and compatibility, blending process parameters, and the relationship between dispersed phase particle size and process parameters; Enable students to understand the basic principles of polymer modification; Familiar with and proficient in common polymer blending systems and filling composite systems; Understand the structural characteristics of polymers themselves, be familiar with and master the basic reaction categories and rules of chemical and surface modification of polymers; Be able to provide insights and plan solutions for complex problems in the field of engineering; Being able to establish socialist core values, have environmental awareness and sustainable development concepts, be able to think and evaluate the rationality and feasibility of polymer modification processes and processes within the legal framework, and be able to showcase one's own ideas in a reasonable manner; Be able to have a macro perspective and balance the design of the entire polymer modification process from multiple aspects such as product performance and benefits, and establish engineering thinking.

Based on the above course objectives, we will reorganize and construct the teaching content. Firstly, the theoretical content (blending thermodynamics, compatibility, chemical modification, etc.) will be taught in an inspiring and guided manner. The performance section is based on the differences in polymer structure and properties, solving engineering problems in practical applications of polymers, including strengthening and toughening, glass transition, crystallization and melting, viscoelasticity, rheological properties, and other special topics. This part of the content has a strong combination of theory and practice. Students learn based on preview tasks and small test questions, and group discussions and reports in discussion areas or classrooms. For the explanation of practical application scenarios of polymers, specific enterprise cases are combined, such as the design of cable formulas with EPDM rubber as the insulation layer, to make the problem comprehensive and include multiple interrelated sub problems. This part of the content belongs to complex engineering problems, which can be completed through pre class case analysis and in class presentation of results. The use of flipped classrooms endows teachers with different roles at different stages, and emphasizes more on students' complete and in-depth learning experiences. Through offline teaching forms such as group debates and case drills, teachers fully discuss and learn key and difficult knowledge and complex engineering cases.

In the teaching process, not only should emphasis be placed on teaching, but also on educating people. A set of four ideological and political case studies, namely "scientific spirit, ideal beliefs, craftsmanship spirit, and low-carbon environmental protection," has been formed to guide students to always adhere to the principles of environmental and sustainable development when designing, developing, and producing polymer products, keeping in mind that "green mountains and clear waters are as valuable as gold and silver", and scientific research should be based on the concept of sustainable scientific development and green ecology. In addition, inviting industry experts and enterprise senior engineers into the classroom, bringing the latest scientific research achievements and specific industrial production processes into the classroom and integrating them into the curriculum, not only stimulates students' interest in learning, broadens their horizons, deepens their understanding of knowledge, but also enables them to fully understand the connection between theory and practice, enabling them to flexibly apply the knowledge they have learned, ultimately achieving a high degree of matching between knowledge acquisition and ability reserves, and cultivating high-quality professional talents.

3.4. Teaching Implementation of Polymer Modification Course

The combination of restructured course content and the "BOPPPS+flipped classroom" teaching mode places more emphasis on cultivating students' subjective initiative in learning and improving their ability to solve complex engineering problems.

(1) Study preview. One week in advance, students are required to preview the courseware, related videos, and preview thinking questions that lead to the next course through learning. This process uses the learning platform's statistical function to check the student's preview status. Communicate separately with students who fail to complete the task points on time.

(2) Focus on learning objectives. Based on the content learned in the next lecture, identify 1-3 key and difficult points, and guide students to focus on learning priorities. Due to clear goals, students are required to conduct online self-study on key and difficult issues in advance, which solves the problem of students not focusing on pre class preview under normal circumstances. Using common polymer products or related scientific phenomena in daily life to set preview points and thinking questions can easily stimulate students' desire for knowledge and arouse their interest in learning. For example, in the chapter on polymer phase separation, students are asked to consider the effect of nucleating agents on the degree of crystallization and grain size of products in real life, such as why some bottles can withstand a temperature of 110 ℃ and some bottles can deform with water at 70 ℃, by setting a thinking question. For example, in the chapter on general plastic processing and modification, students are asked to think about "for polyvinyl chloride, that is, PVC, it can be made into hard aluminum-plastic doors and windows, travel bags with a certain hardness, soft shoe soles, shopping bags, and synthetic leather clothing fabrics. What are these states related to? What are their performance differences? Why can the same material state and performance differ significantly?" Guide students to think about the huge impact of different processing aids on material properties and states, and the laws behind them stimulate their desire to learn, improve their sense of achievement and fun in self-learning.

(3) Before class, assess the student's knowledge reserve for the lecture

By using methods such as learning quizzes, hot topics in discussion areas, and classroom guided questioning, identify areas of interest for students, verify their understanding of the upcoming new knowledge modules, further clarify the learning situation, and based on their mastery of key and difficult points, consider the depth and detail of the lecture's explanation. According to the students' interests, prepare questions for on-site classroom questioning.

(4) Participatory learning combined with flipped classroom reflects the higher-order nature of knowledge

Concentrate some time in the classroom to analyze the key and difficult points, explain their profound principles, model construction, and other key content. During this process, attention should be paid to guiding students to concentrate, following the teacher's train of thought for deduction and verification, and at the same time, paying attention to setting reasonable questions for key and difficult problems, using question and answer forms to strongly urge students to be highly focused, and following the teacher's explanation to quickly and deeply understand scientific principles.

The subsequent flipped classroom section can adopt the method of analyzing classic engineering cases or throwing questions on site, allowing students to think independently or discuss in groups based on the content of this lecture, answer questions or explain their understanding of the problems on stage.

For example, for a production line of chlorinated polyethylene products, the extruder filter screen frequently blocks, and bright crystal particles appear on the filter screen. How to solve the problem of frequent blockage of the filter screen? For such a classic and complex engineering problem, it is necessary to release detailed information such as the specific formula and process parameters of the production line in advance, so that students can immerse themselves in it, think and infer which material the blockage may be, and how to design testing methods to determine the composition of this material? And propose a reasonable solution based on one's own inference. In the face of such problems, it is advisable to adopt methods such as group discussions and team demonstrations, so that each group has the opportunity to present their own research deductions or results, achieve the goal of self-learning and self-improvement for students, and improve their abilities in teamwork, communication, and public speaking and debate.

If there are relatively simple questions, on-site questioning and on-site resolution will be adopted. For example, in the chapter on characterization of polymer morphology, students are asked to think about why non-conductive polymer materials should be sprayed with gold or carbon to improve their conductivity during scanning electron microscopy (SEM) testing? Why is it common to spray some alcohol and then inject the film into liquid nitrogen when observing the cross-sectional morphology of thin film samples prepared by low-temperature fracture method? After the question is raised, students are immediately required to send bullet comments or rush to answer on the Learning Platform. Teachers and students communicate and interact in multiple dimensions and ways, concretizing knowledge and making the context of knowledge coherent. Let students experience that scientific experiments not only require understanding of principles, but also some basic operational skills, further bridging the gap between science and practice.

By flipping the classroom, the traditional teaching model of "one-way teaching" has been transformed into a new classroom model of "teacher-student resonance". Preliminary theoretical knowledge is internalized into the ability to solve complex engineering problems through Q&A and discussion of classic cases.

(5) Review and consolidation and post class quizzes

For the learning content that cannot be fully understood in the classroom, students can review the courseware, key and difficult points, complete relevant assignments, and take quizzes and thinking questions after class through the Learning Pass. Teachers, based on each student's completion of homework, test questions, thinking questions, etc., provide precise strategies and target individuals. This process not only verifies the achievement of teaching objectives, but also enhances the teacher's sense of familiarity with students through personalized tutoring. Teachers are no longer limited by the classroom, and students are no longer limited by time and location. They can use the Learning Platform to learn anytime and anywhere, which can enhance students' interest and initiative in learning, and cultivate their comprehensive abilities.

(6) Teaching Reflection and Evaluation of Teaching Effectiveness

Utilize online data from the Learning Platform to conduct a comprehensive evaluation of teaching and learning throughout the entire process. Based on the information storage and analysis function of the Learning Platform, it is convenient to evaluate the learning effectiveness of students. Through the achievement of teaching objectives, teachers can indirectly evaluate the teaching effectiveness.

By combining precise data recording and analysis of Xuetong with student classroom performance, the entire learning process of students is assessed, avoiding the shortcomings of the traditional mechanical evaluation method of "one exam determines the world". Summarizing and analyzing the various learning data of the implementation class can identify problems, summarize patterns, and provide experience and methods for future teaching.

4. Evaluation methods and teaching effectiveness

4.1. Performance evaluation system

The performance evaluation system consists of two parts: process assessment and outcome assessment, each accounting for 50% of the total. The process assessment includes course assignments accounting for 20%, knowledge tests accounting for 10%, speeches and defense accounting for 10%, classroom performance accounting for 5%, and ideological and political discussions accounting for 5%. This assessment model can more accurately and objectively evaluate the learning situation and effectiveness of students. Teachers can grasp the dynamic whole process of student learning and adjust teaching methods in a timely manner based on learning effectiveness

4.2. Teaching effectiveness

The teaching model based on "BOPPPS+flipped classroom" has achieved enthusiastic interaction between teachers and students, fully mobilizing and stimulating students' interest in learning. Students complete their homework seriously, actively speak and interact in the discussion area, and have a high sitting rate, head up rate, and activity participation in the front row of the classroom. Students' tie scores have improved year by year for three consecutive years

5. Conclusion

In view of the characteristics of the teaching content of Polymer Modification which is rich and abstract, this paper, with the help of the Internet plus model and the "Learning Pass" platform, has realized the improvement of the traditional classroom through BOPPPS+Flipped Classroom, and implemented the "value guidance, knowledge transfer and ability improvement" throughout the whole learning process. This study provides new educational reform ideas for courses related to polymer synthesis, processing, and application in the field of polymer materials and engineering.

Acknowledgments

This work was supported Research and Practice Project on Education and Teaching Reform at North China University of Science and Technology (ZJ2101Y).

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