Curriculum and Teaching Methodology (2025)
Clausius Scientific Press, Canada

DOI: 10.23977/curtm.2025.080504
ISSN 2616-2261 Vol. 8 Num. 5

Integrating CAD/CAE Coursework with Professional Practice: An Innovative Approach for Polymer Materials Engineering Education

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Keywords: Polymer Materials, CAD/CAE Courses, Industry-Immersive Instruction, Teaching Reform, Curriculum-Practice Convergence

Abstract: Addressing evolving industry demands and pedagogical challenges in polymer materials engineering, this study pioneers an integrated approach to bridge CAD/CAE instruction with professional practice. Current limitations in linking theoretical coursework with applied skills are systematically analyzed, revealing critical gaps in student competence development. A novel pedagogical framework is proposed, incorporating industry-aligned polymer case studies into CAD curricula through project-driven methodology. Key innovations include establishing industry-academia partnerships to simulate real-world technical environments, implementing blended theory-practice instruction, and deploying a cross-institutional digital resource platform. This model demonstrates significant potential in advancing students' operational proficiency and innovation capacity, thereby strengthening talent cultivation outcomes for the polymer engineering discipline.

1. Introduction

The major of Polymer Materials and Engineering is an interdisciplinary major that integrates knowledge from multiple disciplines such as materials science, chemistry, mechanics, and technology[1]. It plays an irreplaceable and important role in the development of the national economy and society. With the continuous expansion of the application fields of polymer materials and their products, the demand for professional talents in polymer materials engineering in society is also continuously increasing, showing a trend towards the development of compound and innovative talents[2]. As the cradle for cultivating professional talents in polymer materials engineering, how colleges and universities cultivate high - quality compound talents with a solid theoretical foundation, proficient practical skills, and innovative awareness have become a top priority in higher education reform. In the curriculum system of the polymer materials engineering major, the CAD (Computer - Aided Design) course is a very important professional basic course. It not only lays a solid foundation

for students to learn subsequent professional courses such as mold design and product design but also serves as an important link in transforming the learned theoretical knowledge into practical application abilities[3]. However, the traditional CAD course teaching model is relatively outdated and has many deficiencies, making it difficult to meet the actual needs of talent cultivation in the polymer materials engineering major[4]. Therefore, exploring a new model for the organic integration of CAD course teaching and polymer materials professional practice is of great significance for improving the quality of talent cultivation and enhancing students' practical hands - on abilities and innovative awareness[5].

Domestic and foreign universities have done a great deal of work in the reform of CAD course teaching. Some well - known foreign universities such as the Massachusetts Institute of Technology (MIT) and Stanford University attach great importance to combining CAD teaching with engineering practice and emphasize cultivating students' engineering design and innovative capabilities. They widely adopt teaching methods such as project - based teaching and case - based teaching in CAD courses and maintain close cooperation with enterprises to provide students with rich practical training opportunities. In China, many universities have also made positive attempts and explorations in CAD course reform. For example, they have adopted virtual simulation technology, constructed CAD training platforms, and offered comprehensive engineering training practices, achieving certain results. However, in general, there is still a certain degree of disconnection between CAD course teaching and professional practice, and many universities have not yet formed a mature and effective teaching model. Therefore, it is necessary to further study in depth the teaching models and paths for the integration of CAD courses and professional practice.

The purpose of this paper is to explore a new model for the integration of CAD course teaching and polymer materials professional practice to improve students' professional practical abilities and innovative awareness and provide strong support for the cultivation of talents in the polymer materials engineering major. The main research contents include analyzing the current situation and existing problems, constructing a new teaching model, implementing the new model, and evaluating the teaching effect.

2. Manuscript Preparation

2.1. Characteristics and Existing Problems of CAD Courses

The characteristics of the CAD course are as follows: Most of the course content comes from the mechanical manufacturing industry, such as the design and drawing of mechanical parts and mechanisms. The course generally also involves the basic knowledge of three - dimensional modeling, such as three - dimensional solid modeling, surface modeling, and assembly design, but it is relatively simple. Students need to master basic two - dimensional drawing operations using CAD software, such as drawing points, lines, circles, polylines, and lofts. The traditional CAD course mainly consists of teachers' explanations and demonstrations, with students following along in practice, lacking diverse teaching models such as project - based and inquiry - based teaching. The teaching cases are mostly typical standard parts and devices, lacking examples from emerging product fields. At present, the teaching mode of CAD courses in many schools still follows the previous form, and the following main problems exist.

2.1.1. Disconnection between Course Content and Actual Needs

The existing CAD course content focuses on the training of CAD software operation skills and lacks the combination with the actual applications in polymer materials engineering, such as injection mold design and blow-molding product design, which does not meet the actual needs of

enterprises[6].Students have mastered CAD software operation skills but lack the ability to apply these skills to solve actual engineering problems. Students have mastered CAD software operation skills but lack the opportunities to apply them to actual engineering problems, making it difficult for their practical hands-on abilities and innovative awareness to be effectively exercised

2.1.2. Single Teaching Method

Classroom teaching is mainly based on teachers' lectures on theoretical knowledge, lacking heuristic, inquiry-based, and participatory teaching methods. Students are in a passive state of receiving knowledge, making it difficult for them to actively explore and think independently, which is not conducive to cultivating innovative thinking abilities. The CAD theoretical knowledge learned by students cannot be well transformed into professional skills for solving actual problems, resulting in a disconnection between knowledge and skills.

2.1.3. Lack of Practical Links

The theoretical teaching and practical training links are separated. Practical teaching mainly relies on other links such as graduation design and internships. The CAD course itself lacks opportunities and means to transform the learned knowledge into practical application abilities. Due to the lack of practical training, students' employment abilities and professional qualities such as teamwork and engineering awareness are difficult to be comprehensively cultivated, which is not conducive to their future career development.

Therefore, it is necessary to explore a new teaching model to organically integrate CAD course teaching and polymer materials professional practice, promote the combination of theory and practice,and improve the quality of talent cultivation.

2.2. Teaching Model for the Integration of CAD Courses and Professional Practice

To solve the problem of the disconnection between CAD courses and professional practice, a new teaching model is constructed to organically integrate CAD course teaching and polymer materials professional practice. Specifically, it can be carried out from the following aspects.

2.2.1. Incorporating Professional Actual Cases

In CAD course teaching, actual project cases from polymer materials engineering, such as injection mold design, blow-molding product design, and extruder barrel design, are incorporated to combine abstract CAD theoretical knowledge with professional practice. This allows students to understand the actual applications of CAD software in the field of polymer materials engineering while learning CAD software operations, improving their learning interest and professional identity. Teachers can select typical engineering cases and insert them into the course in an orderly manner according to the teaching progress. For example, when learning three-dimensional modeling, students can be asked to model and analyze the structure of a certain injection product; when learning surface design, students can be asked to design the outer cavity mold surface of a blow-molding bottle.

2.2.2. Project-Driven and Theory-Practice Integrated Teaching Method

Adopt a project-driven teaching model, organize students to carry out project design and implementation with actual engineering projects as the guidance. Each project covers multiple links such as CAD theoretical knowledge learning, three-dimensional modeling practice, and process analysis. Theoretical classroom teaching and practical training are interwoven and mutually promoted to achieve the organic integration of theory and practice. For example, when learning surface

modeling, students can be arranged to complete a comprehensive project of "designing the outer shell of an injection product" in groups, including theoretical learning, three-dimensional modeling, mold flow analysis simulation, and physical model making.

2.2.3. Strengthening School-Enterprise Cooperation and Creating a Simulated Training Environment

Strengthen the in-depth cooperation between universities and polymer materials-related enterprises, make full use of enterprise resources, and jointly build polymer materials engineering training bases inside and outside the school to simulate a real engineering practice environment and provide students with rich practical training opportunities. Inside the school, a virtual simulation training room can be established, equipped with an advanced CAD/CAE/CAM integrated software platform; outside the school, external training bases can be established in cooperation with enterprises to allow students to experience the entire process of polymer processing such as injection molding, blow molding, and extrusion firsthand. At the same time, enterprise engineers can be invited to participate in course teaching to integrate the latest process technologies and production practices into teaching.

2.2.4. Constructing a Course Resource Sharing Platform

Establish a CAD course resource sharing platform to integrate high-quality teaching resources such as teaching case libraries, training project libraries, and virtual simulation software, achieving cross-school resource sharing and improving teaching levels. Each participating university can share its own high-quality teaching resources on the platform and also draw on the excellent practices of other universities. The platform can also integrate polymer materials engineering CAD/CAE/CAM simulation software to provide teachers and students with a convenient virtual simulation training environment. This teaching model helps students master a solid foundation in CAD theory, cultivate engineering practical abilities and innovative awareness, and provides strong support for the cultivation of talents in the polymer materials engineering major.

2.3. Implementation and Effect Evaluation of the Teaching Modeld

2.3.1. Implementation Process of the Teaching Model

The implementation of this teaching model follows a comprehensive and systematic approach, consisting of six key steps that form an integrated workflow. The process begins with curriculum construction, where the CAD course content is restructured based on the talent cultivation objectives of polymer materials engineering. This involves integrating practical application cases from the polymer industry into foundational theoretical instruction and designing project-based teaching modules. This integration enables students to not only master CAD software operations but also understand their practical applications in areas such as mold design and product development.

Concurrent with curriculum development, the model emphasizes faculty development and practical training infrastructure. Teacher training programs focus on enhancing educators' engineering practice capabilities through enterprise internships and specialized training, leading to the formation of industry-academia collaborative teaching teams. On the practical training side, the model establishes both virtual simulation labs equipped with advanced software platforms on campus and real-world engineering environments through external partnerships with enterprises. This dual approach creates a complementary training system that bridges theoretical knowledge with practical application.

Resource support is ensured through the establishment of a course resource sharing platform that

integrates high-quality teaching materials, including case libraries, project repositories, and virtual simulation tools. This platform facilitates cross-institutional resource sharing and continuous improvement of teaching quality. The actual teaching execution employs a project-driven, theory-practice integrated approach, with each project systematically covering theoretical learning, CAD modeling practice, and process analysis. To ensure continuous quality improvement, the model incorporates comprehensive monitoring and feedback mechanisms throughout the entire teaching process, systematically collecting and analyzing feedback from multiple stakeholders to drive iterative optimization of both content and methodologies.

2.3.2. Student Professional Ability Enhancement Evaluation

The implementation of this teaching model has demonstrated a significant positive impact on enhancing students' professional competencies. By integrating actual engineering cases such as injection mold design and blow-molding product design into the CAD curriculum, students are able to contextualize abstract theoretical knowledge within real-world applications, as evidenced by their improved understanding of key concepts through case-based learning. The project-driven approach, which combines three-dimensional modeling exercises with process analysis and theoretical instruction, has effectively strengthened students' practical hands-on abilities, as reflected in their enhanced CAD modeling, process analysis, and virtual simulation skills. This practical focus has also cultivated critical engineering design capabilities, as students develop innovative solutions through comprehensive design projects that require the integration of multi-disciplinary knowledge. Furthermore, the collaborative nature of group projects and industry mentorship programs has fostered essential professional qualities, including teamwork, engineering awareness, and comprehensive vocational competencies. Comprehensive evaluations of student learning outcomes, practical training achievements, and course assessments consistently show marked improvement across these dimensions, confirming the model's effectiveness in bridging the gap between theoretical instruction and professional practice requirements in polymer materials engineering.

2.3.3. Feedback on Teaching Effect and Improvement Measures

By collecting feedback opinions from teachers, students, employers, etc., some deficiencies in teaching can be found, such as the deviation of individual training projects from actual needs and the low utilization rate of the resource sharing platform. According to the feedback, teaching content will be continuously optimized, training conditions will be improved, and resource sharing will be strengthened to continuously improve and perfect this teaching model. Regarding teaching content, the latest technologies, processes, and concepts in polymer materials engineering will be further incorporated into the course content; at the same time, the design of training projects will be optimized to make them more in line with the actual needs of enterprises. Regarding training conditions, the construction of the internal virtual simulation training room and external training bases will be continuously improved to provide students with a high-level practical environment. Regarding resource sharing, publicity efforts will be increased to encourage a large number of teachers to actively participate in the construction of the resource sharing platform, improve the quality and quantity of resources; at the same time, the platform functions will be optimized to enhance usability and attract more teachers and students to use it.

3. Conclusions

This paper explores a new model for the organic integration of CAD course teaching and polymer materials professional practice. It analyzes the main existing problems in the current CAD course teaching and professional practice, such as content disconnection, single method, and lack of practical

links, and clarifies the necessity of reform. A new teaching model is proposed, including measures such as incorporating actual cases, adopting a project-driven teaching method, strengthening school-enterprise cooperation, and constructing a resource sharing platform, starting from multiple aspects such as course content, teaching methods, practical conditions, and resource sharing. The implementation process of this teaching model is formulated, including specific implementation plans such as course construction, faculty construction, training base construction, and resource construction. The teaching effect of this model is evaluated, and it is found that this model can improve students' theoretical knowledge mastery, practical hands-on ability, engineering design and innovative ability, and comprehensive professional qualities. Feedback opinions from all parties are collected, deficiencies are analysed, and improvement measures such as continuously optimizing teaching content, improving training conditions, and strengthening resource sharing are proposed. This teaching model can promote the close integration of CAD courses and professional practice, improve students' professional practical abilities, innovative awareness, and comprehensive professional qualities, and provide a useful exploration for the talent cultivation of the polymer materials engineering major. In general, this study systematically explores a new model for the close integration of CAD course teaching and polymer materials professional practice, not only proposing specific implementation paths in theory but also providing implementation plans and effect evaluations, offering useful references for the reform of CAD course teaching in universities. This model fully reflects the talent cultivation concept of the integration of theory and practice and the mutual support of industry, education, and research, which is conducive to improving the quality of talent cultivation and better meeting the actual needs of the polymer materials engineering industry. Talent cultivation is a systematic project that requires the joint efforts of universities, enterprises, and governments. It is believed that with the joint efforts of all parties, more innovative talent cultivation models will be created to contribute to the sustainable development of polymer materials engineering and related fields.

Acknowledgements

The authors are grateful for the financial support of the Demonstration Course of Triple Innovation Education of Wuyi University: CAD/CAE (KC2024006SC) and Fujian Province Undergraduate Education Reform Research Project (FBJY20230280).

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