Organic Integration of Value Education into Polymer Chemistry Teaching: Exploration and Practice in Normal Universities

Zhenyu Yang,* Chenbo Gao, Xingquan Ruan, Xingming Ruan
School of Chemical and Environmental Engineering, Yancheng Teachers University,
2 Hope Avenue, Tinghu District, Yancheng City 200240, Jiangsu Province, China
* E-mail of the corresponding author: yangzy@yctu.edu.cn

Abstract

Polymer chemistry is one of the most important professional foundation courses for chemistry majors in normal universities. Owing to its abstract theoretical concepts, diverse polymerization mechanisms, and extensive engineering applications, the course plays a significant role in cultivating students' scientific thinking and professional competence. However, traditional polymer chemistry teaching mainly focuses on the transmission of theoretical knowledge, while insufficient attention is paid to value education, scientific spirit, engineering ethics, and social responsibility. Based on the characteristics of polymer chemistry and the educational objectives of chemistry education majors, a series of teaching reforms have been explored. The reform emphasizes the organic integration of value education into professional knowledge through the introduction of national strategic needs, green polymer development, scientific spirit, frontier scientific research, and diversified teaching methods. This teaching model aims to guide students in establishing correct professional values while improving their learning interest, innovative thinking, and comprehensive abilities. Teaching practice indicates that the integration of value education effectively promotes the coordinated development of knowledge acquisition, ability cultivation, and value guidance, thereby improving the overall quality of polymer chemistry teaching.

Keywords: Polymer chemistry; Value education; Teaching reform; Research-informed teaching; Normal university

DOI: 10.7176/JEP/17-7-11
Publication date: July 30th 2026

1. Introduction

Polymer chemistry is a fundamental course for chemistry, materials science, and chemical engineering majors and serves as the theoretical basis for subsequent courses such as polymer physics, polymer materials, and polymer processing[1]. The course covers polymerization mechanisms, molecular structures, molecular weight distribution, polymer properties, and structure–property relationships. Because polymer chemistry integrates theoretical knowledge with engineering applications, it plays an indispensable role in cultivating students' scientific thinking and practical abilities.

With the rapid development of advanced manufacturing, aerospace engineering, biomedical materials, flexible electronics, and sustainable materials, polymer science has become one of the strategic disciplines supporting national technological innovation. Consequently, polymer chemistry education should not only provide students with systematic professional knowledge but also cultivate their scientific spirit, environmental awareness, innovation consciousness, and sense of social responsibility[2].

In China, value education has become an important component of higher education. Rather than existing as an independent course, value education is expected to be organically integrated into professional teaching so that students can simultaneously develop disciplinary knowledge, professional competence, and appropriate values. Polymer chemistry provides abundant opportunities for such integration because many important topics, including high-performance polymers, biodegradable materials, recycling technologies, and advanced functional materials, are closely related to national development strategies and sustainable development goals.

Nevertheless, traditional polymer chemistry teaching still mainly emphasizes the explanation of polymerization reactions, molecular structures, and theoretical calculations. Students often regard polymer chemistry as a subject requiring the memorization of numerous polymerization mechanisms and reaction equations while paying insufficient attention to the scientific significance and engineering value behind these concepts. Furthermore, the connection between textbook knowledge and modern polymer science is relatively weak, making it difficult for students to appreciate the importance of polymer chemistry in scientific research and industrial development[.

To address these problems, we explored a teaching model that organically integrates value education into polymer chemistry. The reform combines professional knowledge with national strategic needs, green chemistry concepts, scientific spirit, frontier research achievements, and diversified teaching approaches. The objective is to cultivate students' professional competence while strengthening their innovation awareness, environmental responsibility, and professional identity.

2. Challenges Present in Polymer Chemistry Teaching

2.1 Insufficient integration of professional knowledge and value education

Traditional polymer chemistry teaching mainly focuses on theoretical knowledge, including polymerization mechanisms, polymer structures, reaction kinetics, and molecular weight control. Teachers generally devote most classroom time to explaining professional concepts and solving examination problems, whereas relatively little attention is paid to the educational values embedded within polymer science.

For example, when introducing free-radical polymerization, ionic polymerization, and condensation polymerization, teaching often concentrates on reaction mechanisms and kinetic characteristics but rarely discusses how these technologies contribute to modern industry and national technological development. Consequently, students regard polymer chemistry as a collection of abstract theories rather than a discipline closely related to scientific innovation and social development.

As a result, professional knowledge and value education are frequently taught independently, making it difficult to achieve the coordinated development of knowledge learning and value cultivation.

2.2 Weak connection between polymer chemistry and engineering applications

Polymer materials have been widely applied in aerospace engineering, electronic information, renewable energy, biomedical engineering, transportation, and environmental protection. Many high-performance polymers have become indispensable strategic materials supporting national scientific and technological development[3].

However, classroom teaching generally introduces polymer materials according to textbook classifications without sufficiently emphasizing their engineering applications. Students may know the structures and properties of polyethylene, polypropylene, epoxy resins, and polyimides but have limited understanding of their practical applications in high-speed railways, aerospace vehicles, flexible electronics, or medical devices[3].

Without practical engineering examples, students often fail to appreciate the importance of polymer chemistry in solving real engineering problems, which weakens both learning motivation and professional identity.

2.3 Insufficient emphasis on green and sustainable polymer development

With increasing global concern regarding environmental protection and carbon neutrality, green chemistry and sustainable polymer materials have become important research directions. Biodegradable polymers, bio-based polymers, recyclable thermosets, and environmentally friendly polymer processing technologies are receiving increasing attention worldwide[4].

Nevertheless, conventional polymer chemistry courses still primarily emphasize traditional petroleum-based polymers. Although biodegradable polymers and green polymerization technologies are occasionally introduced, they are usually treated as supplementary knowledge rather than integrated into the overall teaching framework.

Consequently, students' awareness of sustainable development and environmental responsibility remains relatively weak, limiting their understanding of the future direction of polymer science.

2.4 Limited introduction of frontier scientific research and innovation

Polymer science has developed rapidly in recent years, leading to numerous breakthroughs in self-healing polymers, supramolecular polymers, organic molecular cages, bio-based adhesives, intelligent materials, and functional polymer networks. These advances provide abundant teaching resources for stimulating students' scientific curiosity and innovation awareness.

However, due to limitations in teaching time and traditional teaching habits, classroom instruction is still largely confined to textbook content. Frontier scientific achievements are seldom introduced, and students have relatively few opportunities to understand how fundamental polymer chemistry supports modern scientific research.

Furthermore, students rarely recognize the close relationship between classroom knowledge and scientific innovation. This disconnect reduces their interest in research and weakens their motivation to explore emerging interdisciplinary fields.

2.5 The assessment method is relatively simple

The final written examination generally represents a large proportion of the course assessment. The examination mainly evaluates nomenclature, reaction completion, synthesis, reaction mechanisms, and structural identification.

Although these contents are important, a single written examination cannot fully reflect students' ability to organize organic chemistry knowledge, analyze unfamiliar reactions, and explain chemical concepts.

For chemistry education majors, professional teaching competence should also be appropriately reflected in the course assessment.

3. Teaching Practice for Integrating Value Education into Polymer Chemistry

3.1 Integrating national strategic needs into polymer chemistry teaching

Polymer materials constitute an important foundation for the development of strategic emerging industries. Therefore, classroom teaching should not only explain polymerization mechanisms and polymer structures but also introduce their applications in national key technologies.

During the teaching of engineering plastics and high-performance polymers, practical cases from aerospace engineering, high-speed rail transportation, electronic packaging, and new energy vehicles are incorporated into the classroom. For example, polyimides are introduced together with their applications in flexible electronic devices and aerospace insulation materials, while epoxy resins are discussed in relation to composite materials and advanced structural adhesives. These engineering examples enable students to understand how polymer chemistry supports modern industrial development and national technological innovation.

Meanwhile, current national strategies such as "Made in China 2025", carbon neutrality, and the development of advanced materials are appropriately introduced into classroom discussions. Students are encouraged to analyze why high-performance polymer materials have become indispensable in high-end manufacturing and how polymer scientists contribute to national scientific and technological competitiveness. In this way, professional knowledge is naturally connected with national development, strengthening students' professional identity and sense of responsibility.

3.2 Integrating green chemistry and sustainable development concepts

Green chemistry is one of the most important development directions in polymer science. Therefore, sustainable development concepts are incorporated throughout the polymer chemistry curriculum rather than being introduced as independent supplementary knowledge[4].

When teaching condensation polymerization and polymer degradation, biodegradable polymers such as polylactic acid (PLA) and polycaprolactone (PCL) are introduced as representative examples. Students compare their synthesis methods, degradation mechanisms, and practical applications with those of conventional petroleum-based polymers[4]. Through comparative analysis, students understand the environmental challenges caused by traditional plastics as well as the advantages and limitations of biodegradable materials.

In addition, bio-based polymers, recyclable thermosetting polymers, and closed-loop polymer recycling technologies are incorporated into classroom teaching. Students are encouraged to discuss current environmental issues related to polymer materials and propose possible solutions based on the knowledge learned in class. Such discussions strengthen environmental awareness while helping students recognize the important role of polymer chemistry in achieving sustainable development.

3.3 Strengthening scientific spirit through the history of polymer science

The development of polymer chemistry is closely associated with continuous scientific exploration and technological innovation. Therefore, introducing the history of polymer science provides an effective approach for cultivating students' scientific spirit.

When discussing step-growth polymerization, the pioneering work of Wallace Carothers in developing nylon is introduced to demonstrate how persistent scientific research led to revolutionary industrial products. During the teaching of polymer molecular theory, the contributions of Hermann Staudinger and Paul Flory are presented to illustrate the process through which scientific hypotheses were gradually accepted by the academic community.

Teachers emphasize that scientific discoveries are often achieved through continuous exploration, repeated verification, and long-term persistence rather than accidental success. By introducing the stories of outstanding scientists together with their scientific achievements, students gradually develop rigorous scientific attitudes, innovative thinking, and perseverance in solving scientific problems. Furthermore, classroom discussions encourage students to analyze how scientific theories evolve with technological progress, thereby cultivating critical thinking rather than simple knowledge memorization.

3.4 Introducing research-informed teaching to stimulate innovation awareness

One distinctive feature of polymer chemistry teaching is the close relationship between classroom knowledge and frontier scientific research. Therefore, research-informed teaching has been incorporated into the course by introducing representative research achievements into appropriate teaching chapters.

For example, when discussing polymer crosslinking networks, recent research on bio-based polymer adhesives is introduced to demonstrate how molecular design influences mechanical properties and adhesion performance[4]. During the teaching of dynamic polymer networks, examples involving recyclable polymers and adaptive polymer systems are presented to illustrate current research trends in sustainable materials. In addition, recent advances in organic molecular cages and functional polymer networks are briefly introduced to help students understand how fundamental polymer chemistry contributes to the development of advanced functional materials.

These research cases are not intended to increase teaching difficulty. Instead, they demonstrate the practical value of polymer chemistry and encourage students to connect textbook knowledge with scientific research. Students are also encouraged to read recent review articles, search scientific literature, and participate in undergraduate innovation projects. This research-oriented teaching approach effectively stimulates students' curiosity and innovation awareness while improving their ability to acquire knowledge independently.

3.5 Optimizing teaching methods and assessment mechanisms

Traditional polymer chemistry teaching is generally dominated by teacher-centered lectures. To improve classroom participation, diversified teaching approaches have been adopted[5].

Problem-based learning is introduced throughout the course. Before explaining polymerization mechanisms, teachers first present practical engineering problems or scientific phenomena and encourage students to analyze possible solutions based on their existing knowledge. Classroom discussions, case analysis, and group presentations are also incorporated to strengthen interaction between teachers and students[5].

The assessment system has likewise been optimized. Instead of relying solely on the final examination, students' comprehensive performance is evaluated through classroom participation, literature reading, case analysis, group presentations, and final examinations[6]. Classroom participation accounts for 10% of the final grade, literature discussion and case analysis account for 20%, classroom presentations account for 20%, while the final examination accounts for 50%.

The diversified assessment mechanism not only evaluates students' mastery of professional knowledge but also encourages independent learning, critical thinking, communication skills, and innovation awareness. Consequently, students participate more actively in classroom activities and demonstrate stronger motivation for learning polymer chemistry.

4. Conclusion

Polymer chemistry is an important professional foundation course that plays a significant role in cultivating students' scientific thinking, professional competence, and innovative ability. Based on the characteristics of polymer chemistry and the educational objectives of chemistry education majors, a series of teaching reforms have been explored by organically integrating value education into professional teaching.

The reform focuses on connecting polymer chemistry with national strategic needs, green and sustainable development, scientific spirit, frontier scientific research, and diversified teaching approaches. Rather than separating value education from professional knowledge, the proposed teaching model incorporates educational elements naturally into the explanation of polymer chemistry concepts and engineering applications. This approach effectively enhances students' learning interest, strengthens their professional identity, and cultivates their innovation awareness and sense of social responsibility.

Teaching practice indicates that the organic integration of value education contributes to the coordinated development of knowledge acquisition, ability cultivation, and value guidance. In the future, further optimization of teaching content and teaching methods will continue to improve the quality of polymer chemistry education and provide stronger support for cultivating high-quality chemistry professionals with solid scientific literacy and strong social responsibility.

Acknowledges

The research is financed by the Teaching Reform Project of Yancheng Teachers University (No. 2025YCTCJGSZ09).

References

[1] Ford, W. T. Introducing the Journal of Chemical Education Special Issue: Polymer Concepts across the Curriculum. Journal of Chemical Education, 2017, 94, 1579–1580.

[2] Pienta, N. J. Call for Papers: Polymer Concepts across the Curriculum. Journal of Chemical Education, 2016, 93, 806–807.

[3] Cersonsky et al. Augmenting Primary and Secondary Education with Polymer Science and Engineering.

Journal of Chemical Education, 2017, 94, 1639–1646.

[4] Y. Yang, X. Ji, G. Li. Fully bio-based benzoxazine adhesive with enhanced strength via synergistic supramolecular and covalent cross-linking. ACS Applied Polymer Materials, 2024. 6, 12897–12905.

[5] A. Prince. Does active learning work? A review of the research. Journal of Engineering Education, 2004, 93, 223–231.

[6] Crimmins M. T.; Midkiff B. High structure active learning pedagogy for the teaching of organic chemistry. Journal of Chemical Education, 2017, 94, 429–438.