

Team Project-based Interactive Teaching Method for Light Chemical Engineering Undergraduate Students

Letian Qi, Zhaoyun Lin

Faculty of Light Industry, Qilu University of Technology, Jinan, China

Abstract

Based on the syllabus of the Polymer Chemistry and Physics course in the Light Chemical Engineering program, this study integrates interactive teaching elements comprehensively into the foundational professional curriculum through three dimensions: holistic curriculum design, heuristic teaching interactions, and participatory group projects. These approaches promote the enhancement of students' overall competencies and holistic development. To achieve these objectives, the implementation focuses on systematically reorganizing in-class content and time allocation. By transferring a small portion of low-difficulty and easily comprehensible basic content to self-directed learning outside the classroom, more time is freed for in-depth explanation and discussion of key and challenging topics. The syllabus is refined, and teaching plans are adjusted to place greater emphasis on teamwork. Several group discussions projects, such as "Development of Polymer-Related Industries" and "Polymers in Everyday Life," are introduced to interconnect course content, fostering students' teamwork awareness and collaborative skills. Simultaneously, critical thinking, engineering ethics, and scientific spirit are holistically and systematically integrated into classroom teaching, reinforcing the mission of cultivating both knowledge and character and improving the talent development system.

Keywords

Team project; interactive teaching; light chemical engineering; undergraduate students.

1. Introduction

Professional courses are core elements in the cultivation of engineering talents [1]. By making micro-level adjustments and improvements to the teaching process of "New Engineering" professional courses, it is possible to achieve the strategic goal of enhancing the quality of engineering education. However, professional course content is highly specialized and abstract. Students' intuitive understanding acquired through daily learning is often insufficient to reflect the essential characteristics and internal connections of the subject matter [2]. Without timely practice and effective synthesis after class, students tend to remain at lower levels of cognitive engagement for extended periods, making it difficult to achieve higher-order learning objectives. This phenomenon often results in assessment outcomes where lower-level objectives show high achievement rates, while higher-level objectives remain unmet. To foster active learning under teacher guidance, instructional strategies are needed to prompt students to systematically analyze, compare, abstract, and generalize the content they have learned, thereby achieving higher-order cognitive goals.

The introduction of team-based collaborative projects, where students form their own groups and select topics, effectively encourages students to devote more time and effort during the learning process. This approach helps students proactively synthesize, organize, and apply their knowledge, enabling them to achieve higher-order learning outcomes [3]. In the UK, team project-based teaching has a relatively early history, where instructors design specific topics to

create opportunities for practical application during the teaching process [4]. This method allows students to gain hands-on experience with comparatively lower individual time and effort investments [5]. In contrast, current teaching practices in many professional courses often require students to complete assignments independently, focusing primarily on developing individual capabilities while neglecting the cultivation of teamwork awareness and collaboration skills. This issue is prevalent across engineering institutions.

Therefore, university instructors should systematically and strategically incorporate opportunities for developing teamwork awareness and collaborative skills throughout all teaching stages, ensuring that students' development aligns with contemporary societal needs. Moreover, interactive teaching methods can sustain students' interest in learning while integrating teacher guidance. This approach helps students better understand the intrinsic connections and patterns among knowledge areas, deepening their comprehension and fostering integration of concepts. The key challenges in implementing such methods lie in two main aspects: (1) Building upon existing teaching plans to reasonably redesign curricula, integrate teaching resources, and introduce team-building activities at appropriate stages, thereby progressively cultivating teamwork awareness and advancing the synergy between moral and professional education. (2) Adjusting classroom time allocation based on current course content, organizing and selecting topics effectively, ensuring the successful implementation of each component, and conducting sound evaluations of learning outcomes.

2. Interactive Teaching Design Using Team Projects

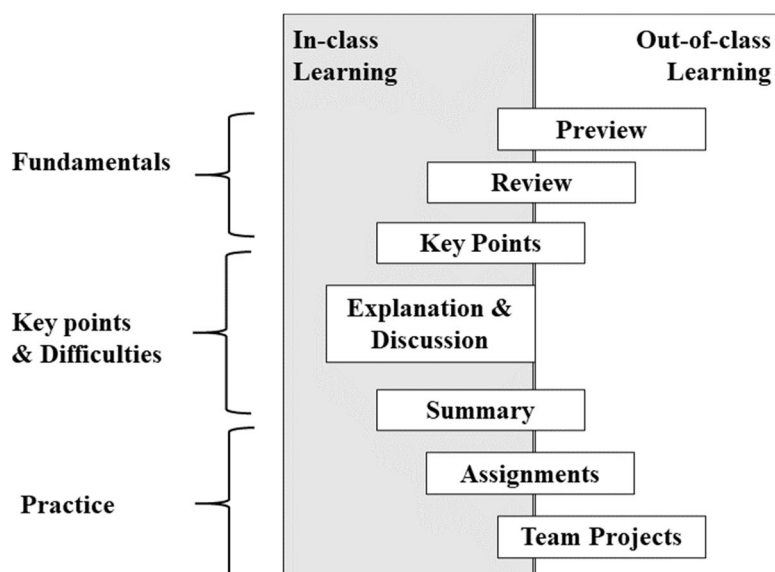
2.1. Design Concept

This initiative is implemented within the Polymer Chemistry and Physics course in the Light Chemical Engineering program. As a foundational professional course, it is offered in the fourth semester with a total of 40 class hours. The course content is mainly divided into two relatively independent parts: "Polymer Chemistry" and "Polymer Physics." Accordingly, the teaching team is organized into two subgroups to prepare focused teaching plans, with overall coordination by the course leader. Each subgroup holds discussions to refine the teaching plan, clarify instructional schedules, and define the scope of student group project topics as well as entry points for interactive teaching. Collaboration between subgroups ensures smooth transitions in the teaching plan and consistency in training objectives across the course. Table 1 shows part of the revised teaching plan for the Polymer Chemistry and Physics course.

In addition, the teaching team coordinates and adjusts the in-class content and time allocation. Leveraging the resources available on the "Wisdom Tree" online teaching platform, a small portion of low-difficulty and easily comprehensible basic content is shifted to self-directed learning outside the classroom. This adjustment frees up class time for advancing group projects as well as for the explanation and discussion of key and challenging topics. After three years of development, the online platform now contains not only routine teaching materials but also high-quality resources from National Excellent Courses and the Shandong Alliance MOOCs, with over 120 resources. The availability of these online resources greatly facilitates students' self-study and review processes, enabling a smooth transition of simple, low-level content from in-class to out-of-class learning. The use of the online platform to support the teaching process effectively releases classroom time, laying a solid foundation for subsequent heuristic teaching interactions and participatory group projects. Figure 1 illustrates the coordinated teaching approach between in-class and out-of-class activities after these adjustments.

Table 1. Teaching plan for the Polymer Chemistry part

Chapter	Key Contents	Interactive Teaching	Team Project
Chapter 1 Introduction	Development of polymer science	Introduce the history of polymers with stories, presenting the basic rules of development	Form groups voluntarily with 5-7 members, and select their topics based on The Development of XXX (Polymer-Related) Industries
Chapter 2 Polycondensation polymers	Thermodynamic analysis and molecular weight control	Discusses the importance of thermodynamic and kinetic analysis with movie "The Bravest"	Check the progress of team project, take their products as examples to illustrate the advantages and disadvantages of the polymer
Chapter 3 Free-radical chain polymerization	From monomer to polymer	Introduce the invention of PE, discuss the influence of monomer structure on polymerization	Take the products in group project to analysis their properties, leading to the comparison between step-reaction and chain-reaction polymers
Chapter 4 Ionic chain reaction and complex coordination polymerization	Mechanism of reactions	Discusses the develop of China polymer industry in relative area, inducing the importance of core technique	Mid-term of the project. Lead the study of project more focus on the chemistry of polymers
Chapter 5 Copolymerization	Kinetics of copolymerization	Use the concept 'alloy' and 'mixed blood' to illustrate copolymerization, following by enhancement of their properties	Adding the concept of copolymers into the project, to improve the overall performance of their products
Chapter 6 Polymer Reactions	Degradation of polymers	Discusses the hot topic 'recycle plastics', illustrating the reason of their poor mechanical performance	Demonstration of group projects

**Figure 1.** The coordinated teaching approach between in-class and out-of-class activities

2.2. Implementation of the Teaching Plan

Table 2. Student Group Topic Selection (2023–2025)

Year	No.	Topic
2023	1	Development of rubber industry
	2	Biomedical polymers
	3	Polymers in electricity cars
	4	Development of plastic industry
	5	Biomacromolecules
	6	Development of fiber industry
	7	Ion-exchange membranes
	8	Polymers for agriculture applications
	9	Polymers in aerospace
	10	Polymers in decorations
	11	Electroluminescence Polymers
2024	1	Development of plastic industry
	2	Spectacle lenses industry
	3	Development of rubber tires
	4	Polymers in aerospace
	5	Polymer films
	6	Development of paint industry
	7	Biomedical polymers
	8	Adhesive polymers
	9	Development of fiber industry
	10	Natural polymers
	11	Polymers in electronic appliances
2025	1	Polymer coatings
	2	Development of PE plastic industry
	3	Natural polymers
	4	Nano-cellulose in new energy industry
	5	Development of rubber industry
	6	Development of PLA industry
	7	Photochromic polymers
	8	Polyhydroxyalkanoates
	9	Eco-friendly polymers
	10	Polymers in optical fiber communication
	11	Polymers in car industry
	12	Development of PS industry
	13	Polyvinylidene fluoride
	14	Biomedical polymers
	15	Development of PTFE industry

The teaching team follows the planned schedule and integrates interactive teaching elements and group project components into different stages of the course. As a core vehicle of this study,

the group project runs throughout the entire teaching process. To align with the course content, the scope of project topics is defined as “The Development of XXX (Polymer-Related) Industries.” Students are required to form groups voluntarily (5–7 members) and select their topics, with a focus on analyzing and interpreting the subject matter from a chemical perspective. The project is designed to encourage students to build on their existing knowledge base, engage in team discussions, and choose topics based on their interests for deeper exploration. Instructors provide guidance on key course concepts and address common issues encountered during project execution, using heuristic teaching methods to integrate interactive elements with course content. Table 2 shows the topic selection for student projects in the Polymer Chemistry and Physics course over three consecutive years (2023, 2024, and 2025).

2.3. Process Control in Teaching

To ensure effective implementation, the teaching team focuses during the first two weeks on guiding students through group formation, initial topic selection, and task allocation within each group. As the course progresses, instructors lead students to gradually deepen and professionalize their research topics. A “midterm review” is incorporated into the middle of the course to address emerging issues, provide timely corrections, and help students summarize and analyze their work to inspire innovative thinking. Project requirements are progressively elevated by narrowing the scope of topics and encouraging in-depth exploration of technical details such as preparation methods, thereby enhancing the professional rigor of the projects. Instructors provide timely classroom feedback, highlighting key and common issues to improve the quality of project outcomes. This approach facilitates a gradual transition of group project content from general science communication to specialized professional topics. On the “Wisdom Tree” platform, projects are structured into two main stages: “midterm review” and “final submission,” focusing respectively on popular science content and professional content. Meanwhile, interactive teaching elements are introduced through discussions and analyses of the progress of team projects, which are organically integrated with course content. This strategy deepens the learning process and reinforces students’ understanding.

2.4. Teaching Summary and Evaluation

The group projects require students to collaborate closely and engage in active discussions while maintaining individual critical thinking. Each group produces a written report and presents their findings through a group presentation. On the Wisdom Tree platform, groups upload a set of deliverables, including presentation slides, a supporting script, and a 5-minute presentation video. To comprehensively evaluate teaching effectiveness, a combined assessment approach of peer evaluation and instructor grading is adopted. Instructors assign comprehensive scores based on group performance, while students complete inter-group peer evaluations after reviewing other groups’ presentations. This assessment method maximizes student engagement, strengthens their sense of collaboration and competition, and effectively promotes peer learning while enhancing students’ communication skills. Figure 2 illustrates the distribution of final project grades for the 2024–25 spring semester. The results indicate that the vast majority of students perform well (88 students, 84.6%), demonstrating the positive outcomes of this teaching approach.

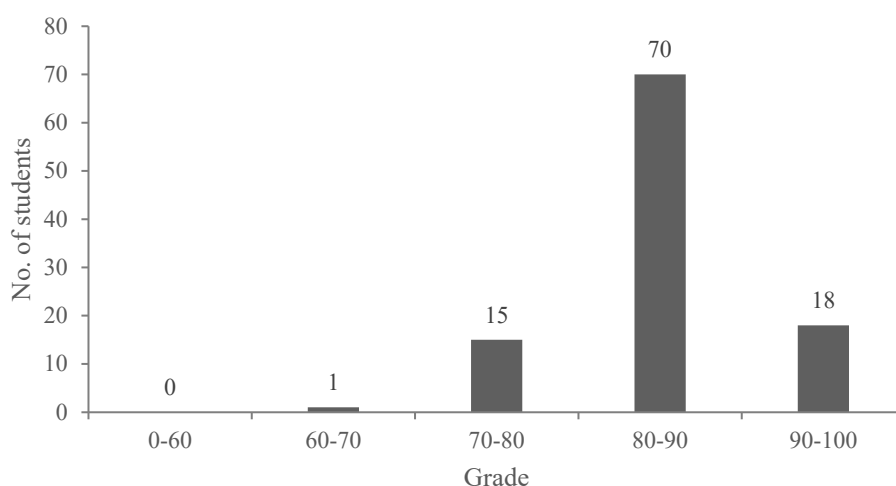


Figure 2. Distribution of Group Project Grades

3. Teaching Evaluation

3.1. Instructor Self-Evaluation

As a science and engineering course, Polymer Chemistry and Physics is characterized by abstract concepts and a high level of difficulty, requiring diverse teaching methods to sustain students' interest and maintain their focus throughout the teaching period. In previous iterations, the teaching team has experimented with various approaches to enhance classroom effectiveness, though these efforts often focus on implementing improvements within individual lessons. Building on prior research and teaching experience, this study places greater emphasis on the overall coherence of the teaching process. The team begins by systematically reviewing the syllabus and lesson plans, coordinating adjustments to content and time allocation to support the integration of group projects. This comprehensive restructuring leads to smoother transitions between course components and strengthens the internal connections among topics. As a result, the logical flow of information is significantly improved, making the material more accessible and easier for students to comprehend.

Applying knowledge in practice remains one of the major challenges in Light Chemical Engineering courses. These professional courses are highly practical yet conceptually abstract and difficult to grasp. Traditionally, the application of learned knowledge is facilitated through after-class exercises and case analyses; however, such approaches often achieve limited success. For Level-2 undergraduates who have largely completed their foundational coursework but have not yet undertaken internships, these professional courses form their "first impression" of the discipline. At this stage, students typically lack sufficient understanding of both the profession and industrial practices, which further hampers their ability to comprehend and internalize abstract concepts. This gap often fosters a sense of "learning is useless," undermining subsequent professional studies and deeper learning. To address this issue, the group project is closely integrated with the course, enriching the teaching format and creating opportunities for practical application. Since students self-organize their teams and select their topics, they remain highly motivated and engaged. In the early stages, the projects focus on popular science topics, such as the development of polymer industries and international comparisons, based on students' chosen topics. By reorganizing classroom content around these student-selected themes, instructors maintain student interest while introducing relevant aspects of China's industrial development. Elements such as patriotism, technological innovation, and sustainable development are thus organically embedded into the teaching process. As the course progresses into the middle phase, students begin to develop a

foundational understanding of professional concepts. Instructors guide them to shift project focus toward more specialized topics. This involves narrowing the scope of topics, for instance, focusing on a specific polymer product. Students investigate its structure, composition, properties, and synthesis methods, supported by midterm evaluations to ensure implementation effectiveness. Positive classroom feedback during this phase reinforces student motivation. Professional analysis based on project content enables instructors to extend discussions into aspects such as production conditions and control, emphasizing the importance of theoretical knowledge and professional rigor. This process conveys to students the values of safe production and meticulous professionalism. The latter phase of the course emphasizes project completion, presentations, and evaluations. Here, instructors focus on consolidating knowledge and conducting systematic analyses. Assessment criteria incorporate research depth, content integrity, and presentation quality. Students also engage in peer evaluations, fostering a sense of ownership and providing preliminary feedback on their overall performance within the cohort. During this stage, the teaching process highlights topics such as copolymers and polymer chemical reactions. By drawing on research examples from student projects and analyzing societal issues, such as those featured in China's 315 Gala (a consumer rights television program), students gain insight into the scientific principles underlying real-world problems. This approach deepens their understanding of professional knowledge, enhances their craftsmanship spirit, and develops their critical thinking skills, contributing to their holistic growth and comprehensive professional development.

3.2. Student Evaluation

The teaching methods applied in this project not only strengthen mutual trust between instructors and students but also enhance teaching effectiveness in the Polymer Chemistry and Physics course. These methods are subsequently extended to other professional courses, such as Lignocellulosic Chemistry, with similarly positive outcomes. Both courses have been well received by students, achieving teaching evaluation scores of 98.94 and 99.90, respectively. At the end of the 2024–2025 spring semester, the course instructor collected anonymous feedback from students in the Class of 2023. Students report a high level of acceptance of the teaching methods, noting strong interactivity and positive learning experiences. Moreover, the successful teaching outcomes inspire students' professional interest. During the implementation of group projects, team members actively engage in further professional research under the instructor's guidance. This process has yielded more than ten high-quality graduate student recruits for the university's master's programs.

4. Conclusion

In summary, this study, based on the Polymer Chemistry and Physics course in the Light Chemical Engineering program, integrates interactive teaching elements holistically into the foundational professional curriculum through three key dimensions: holistic curriculum design, heuristic teaching interactions, and participatory group projects. By using team-based collaborative projects as a vehicle, the approach effectively enhances students' teamwork and collaboration skills while promoting their overall development and comprehensive competencies.

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References

- [1] Pang, J., Zhang, X., Yu, X.N. How to Improve the Teaching Quality of Professional Basic Courses, INTERNATIONAL CONFERENCE ON ADVANCED EDUCATION AND MANAGEMENT (ICAEM 2015), 2015: 541-545.
- [2] Fanguy, M., Wang, H., Lee, K. Critical review of instructional approaches to graduate-level research writing in science, technology, engineering, and mathematics. REVIEW OF EDUCATION. 2025,13(2): e70080. DOI: 10.1002/rev3.70080
- [3] Landaverde-Alvarado, C. Teamwork training and teaming skills to promote the development of professional competencies in chemical engineering students. EDUCATION FOR CHEMICAL ENGINEERS. 2025, 52: 84-100. DOI: 10.1016/j.ece.2025.05.005
- [4] Pla-Pueyo, S., García, F.G., Arnold, D., Gardiner, A. EVALUATION OF GROUP PROJECTS: AN EXAMPLE OF GOOD PRACTICE FROM HERIOT-WATT UNIVERSITY (UK) AND POTENTIAL APPLICABILITY TO EDUCATION STUDENTS AT THE UNIVERSITY OF GRANADA (SPAIN). 9TH INTERNATIONAL CONFERENCE ON EDUCATION AND NEW LEARNING TECHNOLOGIES (EDULEARN17), 2017: 6145-6153.
- [5] Petrescu, A.M.A., Gorghiu, L.M., Gorghiu, G., Bîzoi, M. NEW TRENDS IN TEACHING SCIENCES: A CASE STUDY FROM THE ENGAGE PROJECT. ERD 2017 - EDUCATION, REFLECTION, DEVELOPMENT, FIFTH EDITION. 2018, 41:612-618. DOI10.15405/epsbs.2018.06.72