The goal-oriented teaching reform of “Polymer Chemistry Experiment" course under the background of engineering education professional certification

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Abstract: *Under the background of the engineering education accreditation for the Polymer Materials and Engineering program at Zhongyuan University of Technology, a "goal-oriented" educational philosophy was adopted to guide the reform of the Polymer Chemistry Laboratory course. The reform mainly included the determination of teaching objectives, the integration of ideological and political education into the curriculum, and the establishment of a course evaluation system. A comparison of the course objective achievement between the 2021 and 2022 student cohorts demonstrates that the teaching reform has achieved certain positive results.*

Keywords: *Goal-oriented, Engineering Education Accreditation, Course Objective Achievement.*

1. Introduction

In January 2022, the application for engineering education accreditation for the Polymer Materials and Engineering program at our university was accepted. In May 2023, the self-assessment report was approved, and preparations are now underway for expert on-site evaluation. Seizing the opportunity presented by the engineering education accreditation of the Polymer Materials and Engineering program, the project team has undertaken a reform of the "Polymer Chemistry Laboratory" course based on the standards of engineering education accreditation. This reform involves the restructuring of the course in terms of teaching objectives, teaching methods, and course evaluation system. Guided by a "goal-oriented" educational philosophy, the aim is to inspire students' enthusiasm for practical work, enhance their practical skills, and strengthen their foundational professional competencies.

2. Determination of the Course Objectives for "Polymer Chemistry Laboratory"

The "Polymer Chemistry Laboratory" course is an important experimental course in the Polymer Materials and Engineering program and a compulsory foundational experimental course for students majoring in polymers. Based on the university’s educational mission of "rooted in Henan, facing the whole country, and serving the local regional economic and social development," as well as the professional training goals for high-quality, interdisciplinary engineering and technology talents in the field of polymer materials and engineering, the course supports Graduation Requirement 4 (Research) and Requirement 10 (Communication). Consequently, the teaching objectives were formulated[1].

Through this course, students will reinforce and deepen their understanding of the basic principles and concepts of polymer chemistry, master fundamental methods in polymer chemistry experimentation, and research and analyze solutions to complex engineering problems related to polymer synthesis. Students will conduct experiments safely based on the characteristics of the experimental subjects, correctly collect experimental data, analyze and interpret experimental results, and clearly express their viewpoints on complex engineering problems related to polymer synthesis.

Through the practical training provided by the course, students will develop hands-on skills, observational abilities, literature research skills, the ability to analyze experimental data, and the capability to write scientific reports. This will help cultivate their independent problem-solving abilities and foundational research skills.

The course is conducted in a laboratory setting and adopts a diversified assessment method combining both formative and summative evaluations. The achievement of course objectives is quantitatively calculated, with an analysis of reasons for any unmet objectives. Corrective measures are proposed for the next round of teaching to continuously improve the course's teaching quality. The course objectives' alignment with graduation requirements is shown in Table 1[2].

Table 1: Alignment of Course Objectives with Graduation Requirements

Course Objectives	Supported Graduation Requirements	Supported Graduation Requirement Indicators
1	4 Research	4.1：Be able to research and analyze solutions to complex engineering problems related to polymer materials, based on the principles of polymer materials science, through information retrieval, literature research, or other related methods.
2	4 Research	4.2：Be able to select the appropriate research approach based on the characteristics of the experimental subjects, design the experimental plan, set up the experimental apparatus, conduct experiments safely, and correctly collect experimental data.
3	4 Research	4.3：Be able to analyze and interpret experimental results, and draw reasonable and effective conclusions through information synthesis.
4	10 Communication	10.1：Be able to effectively communicate complex engineering problems related to polymer materials with industry peers and the general public through oral presentations, written reports, charts, and other means, clearly expressing one's viewpoints and addressing inquiries.

The teaching methods for this course mainly include explanations of the experimental process, discussions on the rationality of experimental design, and students' hands-on practice, among other specific teaching activities. These methods effectively provide pathways to achieve the course's teaching objectives. In addition, the continuous improvement and course evaluation mechanism also offer valuable feedback on the quality of teaching activities, thereby better aligning with the teaching objectives.

3. Integration of Ideological and Political Education

The "Polymer Chemistry Laboratory" course contains numerous ideological and political (IP) elements. During the course implementation, attention is given to the integration of IP education, aiming for a subtle and seamless incorporation of these elements, so that they "nourish without being noticed." At the same time, in the context of laboratory teaching, IP education is introduced appropriately based on the students' experimental situations, which better facilitates the collaborative development of teaching and ideological education[3].

For example, during the explanation of experimental safety education and requirements in the "Polymer Chemistry Laboratory" course, the safety regulations and precautions in the laboratory are discussed, cultivating students' understanding and proactive adherence to professional ethics and standards during experiments. When explaining the experimental requirements, the importance of

accurately collecting experimental data is emphasized, fostering students' integrity and trustworthiness.

In each experimental project, through explaining the correct operation of instruments and the influence of process parameters on experimental results, students are encouraged to develop a spirit of craftsmanship with a focus on excellence. Through selecting different reaction conditions in various experimental projects, students are nurtured to embrace scientific exploration. During the defense process, through experiment summaries and reflections, students' dialectical thinking is cultivated.As shown in Table 2.

Table 2: Ideological and Political Education Teaching Design

Serial Number	Ideological and Political Education Teaching Objectives	Experimental Content	Integration Points of Ideological and Political Education
1	Cultivate students' integrity and professional character, and help them understand and actively practice professional ethics and standards during experiments.	Experimental Safety Education and Experimental Requirements	During experimental safety education, the laboratory safety regulations and precautions are explained, cultivating students' understanding and proactive adherence to professional ethics and standards during the experiment.
			When explaining the experimental requirements, the importance of accurately collecting experimental data is emphasized, fostering students' integrity and professional character.
2	Cultivate students' spirit of craftsmanship with a focus on excellence and their spirit of scientific exploration.	Experiment 1: Hydrolysis (Alcoholysis) of Polyvinyl Acetate Experiment 2: Bulk Polymerization of Methyl Methacrylate Experiment 3: Suspension Polymerization of Styrene Experiment 4: Emulsion Polymerization of Vinyl Acetate Experiment 5: Aldol Condensation of Polyvinyl Alcohol	In each experimental project, the correct operation of instruments and the impact of process parameters on experimental results are explained, fostering students' spirit of craftsmanship with a focus on excellence.
			In each experimental project, different reaction conditions are selected to cultivate students' spirit of scientific exploration.
3	Cultivate students' dialectical thinking.	Defense	During the defense process, students' dialectical thinking is nurtured through experiment summaries and reflections.

4. Construction of the Course Evaluation System

This course is a graded course, and it uses a combination of summative assessment (experimental report) and formative assessment (experimental plan, experimental operation, defense) for evaluation. The experimental report accounts for 40%, primarily assessing students' ability to analyze and interpret experimental results, and to draw reasonable and effective conclusions through information synthesis, ultimately producing an experimental report. The formative assessment accounts for 60%, with the experimental plan accounting for 20%. This primarily assesses students' ability to clarify the experimental plans for the hydrolysis (alcoholysis) of polyvinyl acetate, bulk polymerization of methyl

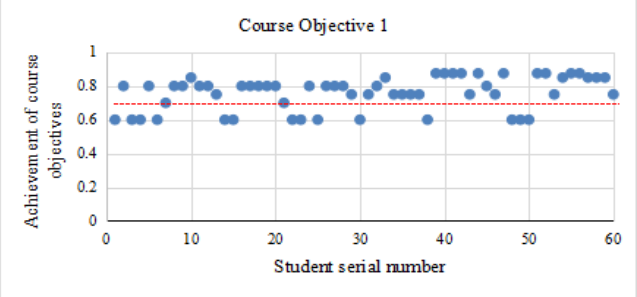
methacrylate, and aldol condensation of polyvinyl alcohol, through information retrieval, literature research, or other methods, as well as their ability to research and analyze the experimental plans for suspension polymerization of styrene and emulsion polymerization of vinyl acetate. The experimental operation accounts for 30%, mainly assessing students' ability to safely conduct polymer synthesis experiments and correctly collect experimental data according to the experimental plan. The defense accounts for 10%, primarily assessing students' ability to effectively communicate, through oral reports, regarding issues related to polymer synthesis reactions, clearly express their viewpoints, and respond to inquiries, as shown in Table 3[4].

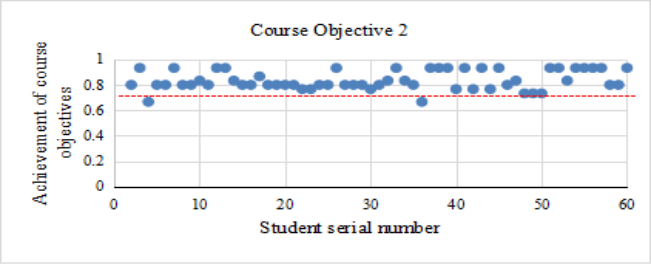
Table 3: Construction of the Polymer Chemistry Laboratory Course Evaluation System

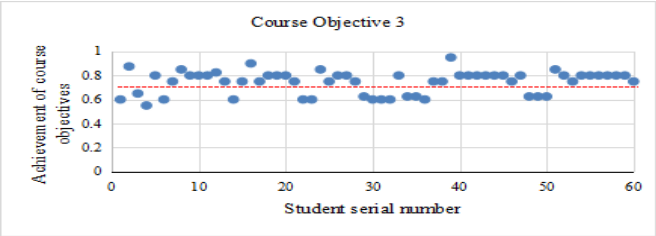
Assessment Method	Assessment Content	Corresponding Course Objectives	Scoring Criteria	Assessment Weight
Experimental Plan	Able to clarify the experimental plans for the hydrolysis (alcoholysis) of polyvinyl acetate, bulk polymerization of methyl methacrylate, and aldol condensation of polyvinyl alcohol, as well as research and analyze the experimental plans for suspension polymerization of styrene and emulsion polymerization of vinyl acetate. (20 points)	1	Graded Scoring Rubric Graded Scoring	20%
Experimental Report	Able to analyze and interpret experimental results, and draw reasonable and effective conclusions through information synthesis, ultimately producing an experimental report. (40 points)	3	Student Performance Scoring Rubric Graded Scoring	40%
Experimental Operation	Able to safely conduct polymer synthesis experiments according to the experimental plan and correctly collect experimental data. (30 points)	2	Student Performance Scoring Rubric Graded Scoring	30%
Defense	Able to effectively communicate, through oral reports, regarding issues related to polymer synthesis reactions, clearly express one's viewpoints, and respond to inquiries. (10 points)	4	Student Performance Scoring Rubric Graded Scoring	10%

5. Achievement of Course Objectives and Continuous Improvement

Taking the achievement of course objectives for the 2021 cohort of Polymer Materials and Engineering students as an example, Figure 1 shows a scatter plot of the achievement of the four course objectives for the 2021 cohort[5].







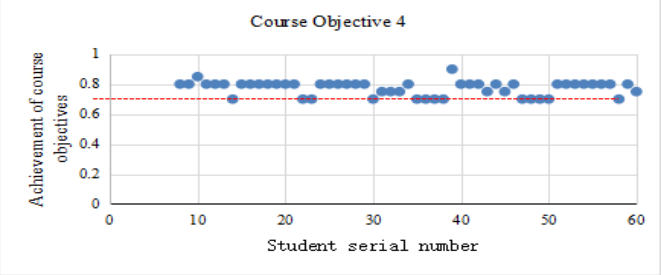


Figure 1: Course Objective Achievement Results

From the results, it can be seen that among the 60 students, 0 students achieved a course objective 1 actual achievement value ≥ 0.90, accounting for 0%; 33 students had an actual achievement value between 0.8 and 0.9, accounting for 55%; 13 students had an actual achievement value between 0.7 and 0.8, accounting for 21%; and 14 students had an actual achievement value < 0.7, accounting for 23%. The percentage of students with an actual achievement value lower than the expected target of 0.70 for course objective 1 is 23%, indicating that 23% of the students did not meet the expected requirements for course objective 1.

For course objective 2, among the 60 students, 20 students achieved an actual achievement value ≥ 0.90, accounting for 33.3%; 29 students had an actual achievement value between 0.8 and 0.9, accounting for 48.3%; 9 students had an actual achievement value between 0.7 and 0.8, accounting for 15%; and 2 students had an actual achievement value < 0.7, accounting for 3.3%. This indicates that 3.3% of the students did not meet the expected requirements for course objective 2.

For course objective 3, among the 60 students, 2 students achieved an actual achievement value ≥ 0.90, accounting for 3.3%; 29 students had an actual achievement value between 0.8 and 0.9, accounting for 48.3%; 12 students had an actual achievement value between 0.7 and 0.8, accounting for 20%; and 17 students had an actual achievement value < 0.7, accounting for 28.3%. This indicates that 28.3% of the students did not meet the expected requirements for course objective 3.

For course objective 4, among the 60 students, 1 student achieved an actual achievement value ≥ 0.90, accounting for 1.67%; 38 students had an actual achievement value between 0.8 and 0.9, accounting for 63.3%; 21 students had an actual achievement value between 0.7 and 0.8, accounting for 35%; and no students had an actual achievement value < 0.7. Therefore, the achievement values for course objectives 1, 2, 3, and 4 all exceeded the expected achievement values. However, course objective 1 showed a deficiency in students' ability to conduct research, design process flows, and experiment plans based on the characteristics of the experimental subjects. Course objective 3, regarding the ability to analyze and interpret experimental results and draw reasonable and effective

conclusions, did not meet the expected level of achievement. Continuous improvements should be made in these areas[6].

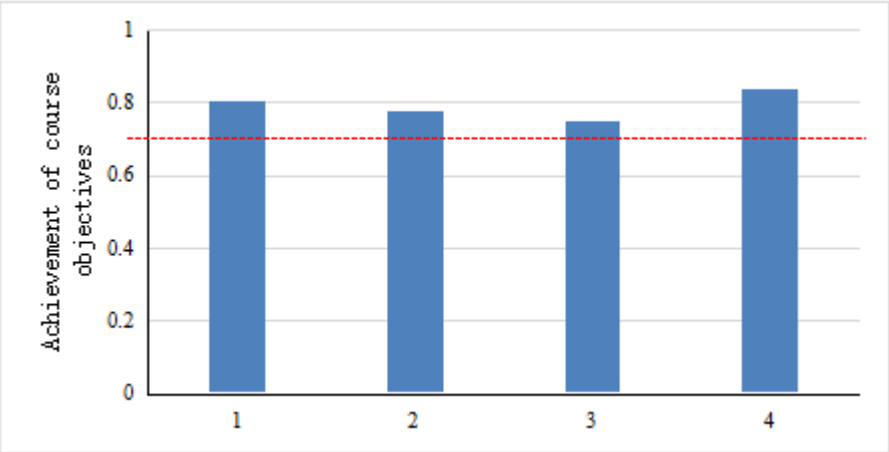


Figure 2: Achievement Evaluation Results of the Polymer Chemistry Laboratory Course Objectives for the 2021 Cohort

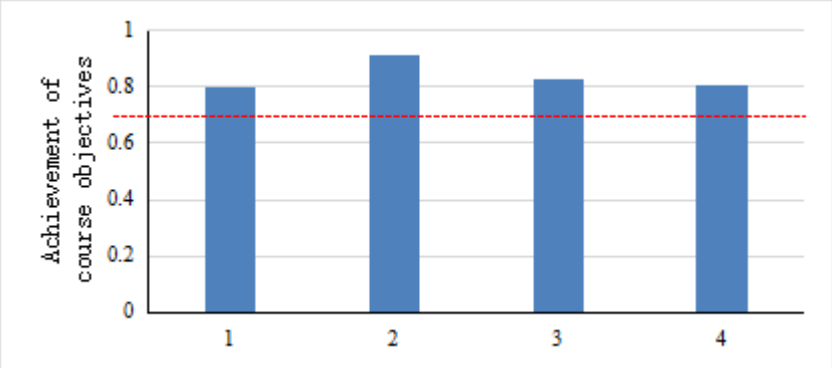


Figure 3: Achievement Evaluation Results of the Polymer Chemistry Laboratory Course Objectives for the 2022 Cohort

Figures 2 and 3 are the bar charts showing the course objective achievement for the 2021 and 2022 cohorts of Polymer Materials and Engineering students, respectively. As can be seen from the charts, the expected achievement value for each course objective is 0.70. The achievement values for course objectives 1-4 for the 2021 cohort were 0.758, 0.838, 0.744, and 0.733, respectively. For the 2022 cohort, the achievement values for course objectives 1-4 were 0.797, 0.913, 0.825, and 0.803, all of which are higher than those of the 2021 cohort. This indicates that the continuous improvement efforts have shown significant results[7].

Conclusion

In the context of the engineering education accreditation for the Polymer Materials and Engineering program at our university, a "goal-oriented" educational philosophy was adopted to guide the related teaching reforms for the Polymer Chemistry Laboratory course. These reforms mainly include the determination of teaching objectives, the integration of ideological and political education, and the establishment of a course evaluation system. A comparison of the course objective achievement between the 2021 and 2022 cohorts shows that the teaching reforms have achieved certain positive results.

Fund Projects

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