# 6-year Tracking Analysis of Learning Effectiveness Evaluation Data for the Course "Environmental Protection and Cleaner Production in Chemical Industry" under the Background of China Engineering Education Accreditation

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**Abstract.** China Engineering Education Accreditation (CEEA) is the most authoritative specialized accreditation for undergraduate engineering education in China. It is an important way for higher education institutions to improve the quality of engineering education and can also produce positive effects on the teaching of specific courses. This work selected the course "Environmental Protection and Cleaner Production in Chemical Industry" in the Chemical Engineering and Technology major at Jianghan University as the research object, tracked the teaching process from 2019 to 2024, collected and calculated various learning effectiveness evaluation data such as student scores, grade distribution, degrees of achievement for course objectives. Based on the analysis of the above data, the teaching and learning effectiveness over the past 6 years has been clarified, and the specific impact of CEEA on the teaching effectiveness and student development quality has been further figured out. The analysis results indicate that, the overall teaching and learning effectiveness of this course was good in the past 6 years under the guarantee of the CEEA continuous improvement mechanism. The various evaluation data of learning effectiveness such as student scores, grade distribution, and degrees of achievement for course objectives have been steadily improved. CEEA can not only ensure the teaching and learning effectiveness of a specific course, but also improve students' comprehensive abilities.

**Keywords:** China Engineering Education Accreditation, “Environmental Protection and Cleaner Production in Chemical Industry”, Learning effectiveness evaluation data, Data analysis, Tracking analysis, Digital evaluation

## 1 Introduction

Engineering education has played an irreplaceable role in the formation and development of the industrial system of a country[1]. At present, improving the quality of engi-


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neering education is of great significance for China's strategy of becoming a technological powerhouse[2]. China Engineering Education Accreditation (CEEA) is the most specialized accreditation for undergraduate engineering education in China, and it is an important way for Chinese higher education institutions to improve the quality of engineering education[3]. CEEA aims to improve the quality of engineering education, promote the connection between engineering education and industry, and enhance the global competitiveness of engineering graduates[4]. In recent years, the social recognition of CEEA has been increasing, and engineering majors in various universities in China are actively applying for this accreditation[5]. Chemical Engineering and Technology (CET) major at Jianghan University passed the accreditation of CEEA in 2021 and the mid-term audit in 2024, and the accreditation is still valid. At present, all courses in this major at Jianghan University have implemented the CEEA mechanism.

In recent years, researches[6-9] have shown that CEEA can not only ensure that students meet industry recognized quality standards, but also promote the cultivation of students' comprehensive qualities and abilities, enhance their employment competitiveness, expand their international perspectives, and facilitate their continuous learning and self-improvement. In addition, CEEA can exert remarkably positive effects on the teaching of specific courses[10]. This work selected the course "Environmental Protection and Cleaner Production in Chemical Industry" in the CET major at Jianghan University as the research object, tracked the teaching process from 2019 to 2024, and collected evaluation data on course learning effectiveness, including student scores, grade distribution, and degrees of achievement (DOA) for course objectives. Based on the analysis of the above data, the teaching and learning effectiveness over the past 6 years has been clarified, and the specific impact of CEEA on the teaching effectiveness and student development quality has been further figured out. This work can provide some reference for undergraduate engineering majors planning to participate in the accreditation of CEEA.

# 2 Research Objects and Methods

## 2.1 Introduction of the Course

"Environmental Protection and Cleaner Production in Chemical Industry" is an elective course for CET major at Jianghan University, mainly composed of environmental pollution control technology and cleaner production in chemical industry. This course focuses on the chemical industry and applies principles of environmental engineering to explain the sources, hazards, and prevention and control technologies of pollution in chemical industry. It also introduces the emergence, development, and application of concepts such as cleaner production, circular economy, and sustainable development. It is a professional technical course that closely integrates basic theory with engineering technology, and has a wide range of engineering application value. This course has four objectives, and the correspondence between course objectives and indicator points of graduation requirements is shown in Table 1.

**Table 1.** The correspondence between course objectives and indicator points of graduation requirements.

| Course Objectives | Indicator Points of Graduation Requirements |
|---|---|
| Objective 1 | Indicator point 3-4: Consider constraints such as safety, health, laws, culture, and environment in the design. |
| Objective 2 | Indicator point 6-2: Able to understand, analyze, and evaluate the impact of complex engineering problem solutions and project implementation in chemical processes on society, health, safety, laws, and culture, and understand the responsibilities that should be undertaken. |
| Objective 3 | Indicator point 7-2: Able to focus on and evaluate the impact of complex engineering problems in chemical processes and production on environmental protection and sustainable social development. |
| Objective 4 | Indicator point 7-1: Understand and comprehend the concept, connotation, and significance of environmental protection and social sustainable |

## 2.2 Research Objects

The research objects are the course of "Environmental Protection and Cleaner Production in Chemical Industry" and students who have learned it. This course first started in 2019 and has been taught continuously for 6 years. Over the past 6 years, a total of 444 students majoring in CET at Jianghan University have learned this course. For the convenience of distinction, these students were divided into six batches according to the teaching years.

## 2.3 Data Sources

Since 2019, the teaching team has been collecting learning effectiveness evaluation data for this course, including regular grades, final exam grades, overall assessment grades, and so on. All basic data are sourced from the scores of classroom Q&A, homework, major project on special topics, and final exam.

## 2.4 Data Analysis Methods

After obtaining the basic data, the teaching team calculated the data to obtain different evaluation indicators for learning effectiveness. In this work, the evaluation indicators mainly include student scores, grade distribution, and DOA of course objectives. The specific calculation and analysis methods are as follows:

### *2.4.1 Student Scores*

Student scores mainly include scores of classroom Q&A, homework, major project on special topics, final exam, regular grades, and overall assessment grades. Each student's grades are scored using a percentage scoring system, and the average scores were calculated for all students in the same teaching year.

### 2.4.2 Score Distribution

The scores of students were classified and counted according to a five-level system, and the classification standard is shown in Table 2. After that, score distribution charts were created based on the five-level distribution of student scores within the same teaching year.

**Table 2.** The relationship between students' grades and scores in the five-level system.

| Grade | Fail | Pass | Medium | Good | Excellent |
|---|---|---|---|---|---|
| Score range | Score<60 | 60≤Score<70 | 70≤Score<80 | 80≤Score<90 | 90≤Score≤100 |

### 2.4.3 DOA of Course Objectives

The DOA of course objectives reflect the students' achievement of the teaching objectives. By calculating and analyzing the DOA, the teaching content can correspond to the course objectives, which plays an important role in cultivating the knowledge, ability and quality of CET major students. This course has four objectives, and the relationship between each objective and the assessment process is shown in Table 3.

**Table 3.** Assessment stages of course objectives and score composition.

| Course Objectives | Regular Grades | | | Final Exam Grades | Total |
|---|---|---|---|---|---|
| | Classroom Q&A | Homework | Major Project on Special Topics | | |
| Objective 1 | — | — | 8% | 6% | 14% |
| Objective 2 | 4% | 16% | — | 35% | 55% |
| Objective 3 | — | — | 7% | 11% | 18% |
| Objective 4 | — | — | 5% | 8% | 13% |
| Total | 40% | | | 60% | 100% |

The specific calculation formula for the DOA of course objectives involved in this work is shown in equation (1):

$$A_i = \frac{P_i}{T_i} \times 60\% + \frac{Q_i}{S_i} \times 40\%, \ (i=1, 2, 3 \ldots n) \tag{1}$$

Where $A_i$ represents the average value of DOA for the objective i in a certain teaching year, $T_i$ represents the theoretical score of the objective i in the final exam paper, $P_i$ represents the actual average score of relevant questions in that year, $S_i$ represents the theoretical score of the objective i in regular grades, and $Q_i$ represents the actual average score of the corresponding regular grades in that year. On this basis, $P_i$ and $S_i$ can be replaced with individual student's final exam scores and regular grades, respectively, and the DOA for each individual student can also be calculated out[11, 12].

# 3 Results and Discussion

## 3.1 Analysis of Student Scores

Different average scores over the past 6 years were collected and analyzed in this work. Figure 1(a) shows the trends of three types of average scores. The changes in the average scores of classroom Q&A and homework are relatively small, with the former stabilizing above 90 and the latter around 88. Compared with them, the average score of the major project has a larger variation. During the process of completing the major project, students need to form study groups and complete various tasks such as literature review, PPT production, presentation, and defense. Obviously, it is more difficult and requires higher comprehensive abilities. In 2019, the average score of the major project was only 79.26, but after 2021, the value can stabilize above 88. This indicates that students' comprehensive abilities have been improved under the CEEA mechanism.

Figure 1(b) shows the trends of the average values for regular grades, final exam grades, and overall assessment grades. The average value of regular grades is significantly higher than that of final exam grades, while the average value of overall assessment grades is between them. The regular grades are mainly evaluated based on the completion of classroom Q&A, homework, major project on special topics. The difficulty of classroom Q&A questions is relatively low, and there is ample time for answering homework and major project, resulting in higher grades. However, the final exam requires concentrated completion within 2 hours, with a large number of more difficult questions, resulting in lower scores than regular grades. In addition, with the increase of teaching year, the average values of the three grades generally show a trend of "decline-rise-decline". Taking the average score of the overall assessment grades as an example, the values from 2019 to 2024 were 80.30, 78.79, 84.32, 88.06, 84.71, and 84.51, respectively. Except for 2020, the values have been higher than 80 in the other 5 years. This indicates that the overall teaching and learning effectiveness is good. In addition, the trends in the overall assessment grades and final exam grades are highly similar, indicating that the final exam score is a key factor in determining the overall assessment grades. According to the above analysis, it can be seen that the ability of students in CET major to complete complex learning tasks has been strengthened under the guarantee of the CEEA mechanism.

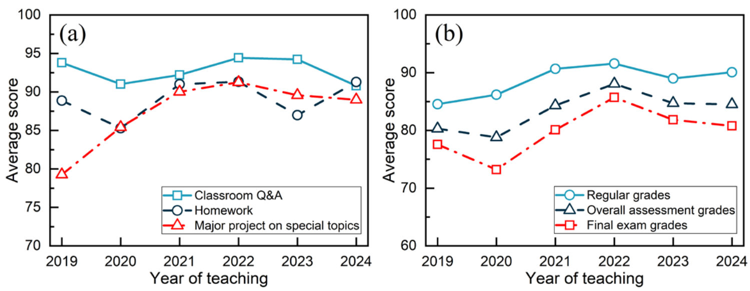


**Fig. 1.** The trends of various average scores of students in different teaching years (a: classroom Q&A, homework, major project on special topics; b: regular grades, final exam grades, overall assessment grades).

## 3.2 Analysis of Score Distribution

Distribution charts of regular grades, final exam grades, and overall assessment grades are shown in Figure 2, 3, and 4, respectively. And the proportion of students at each grade level over the past 6 years is exhibited in Table 4.

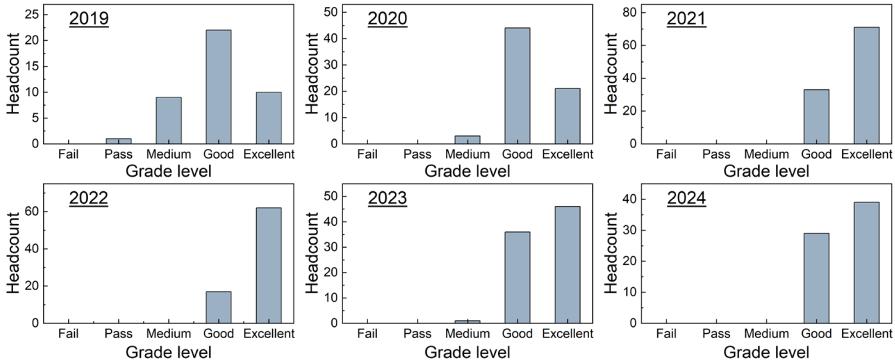


**Fig. 2.** The distribution charts of students' regular grades in different teaching years.

Figure 2 shows the distribution of regular grades. The grades were mainly distributed between good and excellent levels except in 2019. And all students' regular grades are not lower than the good level in 2021, 2022, and 2024, especially. Table 4 collects overall data over 6 years, and it can be seen that over 96% of students have achieved good or excellent regular grades. The above charts and table collectively demonstrate that students scored well in the assessment of classroom Q&A, homework, and major project on special topics.

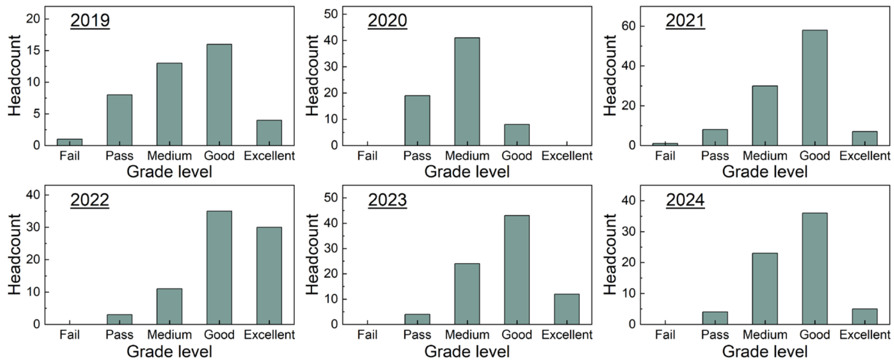


**Fig. 3.** The distribution charts of students' final exam grades in different teaching years.

Figure 3 shows the distribution of final exam grades. Compared to regular grades, the distribution of final exam grades is more dispersed. The proportion of students with medium and pass levels has increased, and students who achieved fail grade appeared in 2019 and 2021. Nevertheless, the number of students with good level was the highest in each of the other years except for 2020. In addition, the proportion of students with good and excellent levels is only 57.20% in Table 4, which is significantly lower than that for regular grades. This phenomenon is consistent with the pattern in Figure 1(b). The teaching team should conduct in-depth analysis of the exam papers and then prescribe targeted measures to improve the final exam grades in the future.

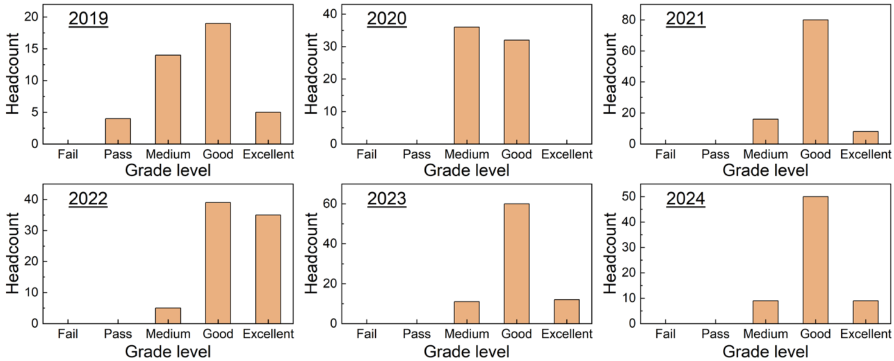


**Fig. 4.** The distribution charts of students' overall assessment grades in different teaching years.

Figure 4 shows the distribution of overall assessment grades. The grades in other years are not lower than medium level except in 2019. The proportion of students with good and excellent levels in 2021-2024 is higher than that in 2019 and 2020, indicating that the grades were gradually improving, and the teaching and learning effectiveness was also improving. According to Table 4, the proportion of students with good and excellent levels is 78.60% over 6 years, while no student failed. The above results all indicate that the overall assessment grades are good, and the overall teaching and learning effectiveness of the course is good. It also indicates that the implementation of the CEEA mechanism can effectively ensure the teaching and learning effectiveness.

**Table 4.** The proportion of students at each grade level in their regular grades, final exam grades, overall assessment grades over the past 6 years.

| Grade levels / Types of Grades | Fail | Pass | Medium | Good | Excellent |
|---|---|---|---|---|---|
| Regular Grades | 0 | 0.23% | 2.93% | 40.77% | 56.08% |
| Final exam grades | 0.45% | 10.36% | 31.98% | 44.14% | 13.06% |
| Overall assessment grades | 0 | 0.90% | 20.50% | 63.06% | 15.54% |

### 3.3 Analysis of DOA for Course Objectives

The average values of DOA for course objectives in different teaching years are shown in Table 5 and Figure 5. Course objective 1 mainly tests students' understanding of environmental pollution in chemical industry, as well as the connotation and importance of pollution control. It focuses on the acquisition of students' ability to consider constraints of safety, health, laws, and environment in chemical industry. The average value of DOA in every year has been much higher than the qualified value of

0.60. Except for 2019, the values in other years remained around 0.90, which were high and stable. The above data indicates that students have mastered relevant knowledge and methods, and have acquired corresponding abilities.

**Table 5.** The summary data on the average values of DOA for all course objectives in different teaching years.

| DOA \ Year of classes | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | Average Value |
|---|---|---|---|---|---|---|---|
| Objective 1 | 0.82 | 0.97 | 0.90 | 0.93 | 0.89 | 0.89 | 0.90 |
| Objective 2 | 0.80 | 0.72 | 0.81 | 0.90 | 0.80 | 0.81 | 0.81 |
| Objective 3 | 0.79 | 0.82 | 0.92 | 0.85 | 0.92 | 0.90 | 0.87 |
| Objective 4 | 0.78 | 0.83 | 0.81 | 0.78 | 0.89 | 0.88 | 0.83 |

Course objective 2 mainly tests students' mastery of the basic knowledge for preventing and controlling the three wastes and physical pollution in chemical industry, with a focus on whether they have acquired the ability to identify the impact of engineering solutions on society, health, laws, and culture in chemical industry, and whether they understand the responsibility of preventing adverse effects. The average value of DOA for objective 2 in every year has been higher than the qualified value of 0.60, indicating that students have mastered relevant knowledge and methods, and have acquired corresponding abilities. It is worth noting that the value was only 0.72 in 2020. After analyzing the basic data, it was found that students had poor performance in completing calculation questions during the final exam in 2020. Therefore, the teaching team promptly proposed improvement measures and strengthened training for calculation questions in subsequent teaching years. Afterwards, the values were not lower than 0.80, indicating that the continuous improvement measures have produced good results.

Course objective 3 mainly tests students' mastery of basic knowledge such as the content and implementation methods of cleaner production, with a focus on whether they have acquired the ability to evaluate the impact of solutions on environmental protection and social sustainable development in chemical industry. The average value of DOA for objective 3 in every year has been much higher than the qualified value of 0.60, and the values in other years are above 0.80 except for 2019. The above data indicates that students have mastered relevant knowledge and methods, and have acquired corresponding abilities.

Course objective 4 mainly examines students' mastery of the basic knowledge of environmental protection, circular economy, and sustainable development. The average values of DOA for objective 4 in the past 6 years have been higher than the qualified value of 0.60. The value has remained around 0.80 in every year. The above data indicates that students have mastered relevant knowledge and methods, and have acquired corresponding abilities.

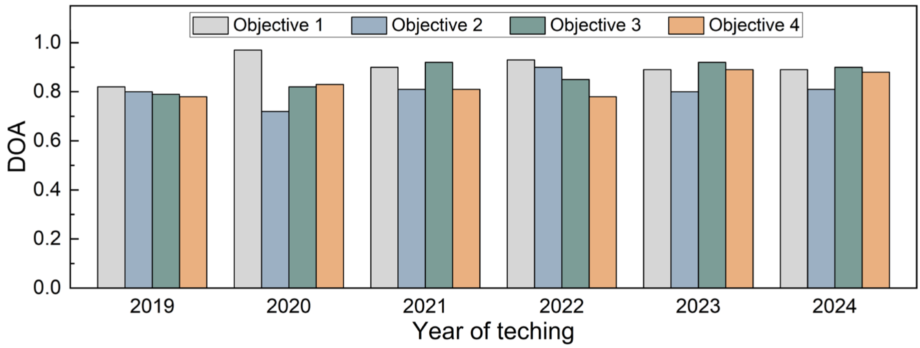


**Fig. 5.** The average values of DOA for all course objectives in different teaching years.

In order to understand the achievement status of each student, the teaching team compiled the scatter plots of each student's DOA for all course objectives in different teaching years. The plots are shown in Figure 6, each small hollow circle in the figure represents the DOA value of a course objective for a single student. The horizontal dashed-dotted lines correspond to the qualified value of 0.60, while the horizontal dashed lines represent the average values of DOA for the course objectives in each year.

For course objective 1, 1 student achieved a DOA below 0.60 in 2019, indicating unsatisfactory results. The teaching team promptly proposed and implemented improvement measures in subsequent teaching years. Therefore, no student's DOA was lower than 0.60 in the next 5 years, and the average value of DOA for each teaching year from 2020 to 2024 was higher than the value in 2019. For course objective 2, 3 students achieved a DOA below 0.60 over the 6-year period, with a failure rate of 0.68%. Considering that the proportion of difficult questions in final exam was relatively high, the DOA of this objective was relatively good. For course objective 3, there were 3 and 1 students whose abilities were not achieved in 2019 and 2020, respectively. In the next 4 years, all students' abilities were achieved, and the average values of DOA in each year were above 0.80. From the perspectives of the number of unqualified individuals and the annual average values of DOA, the achievement status of objective 3 has gradually improved, which is also the positive effect of CEEA's continuous improvement mechanism.

For course objective 4, the achievement status in 2022 was poor, with 13 people achieving a DOA below 0.60, and the failure rate of achievement in that year reached 16.46%. After comparative analysis, it was found that students encountered difficult circular economy analysis questions in final exam and they scored poorly in 2022. These questions combine practical production and requires students to analyze and judge the questions using the concept and characteristics of circular economy. It is comprehensive and difficult for them to handle. After discovering the above problems, the teaching team introduced complex circular economy related cases in subsequent classroom teaching, encouraging and guiding students to analyze and exercise their corresponding abilities. As a result, the achievement status of students' abilities significantly improved in 2023 and 2024.

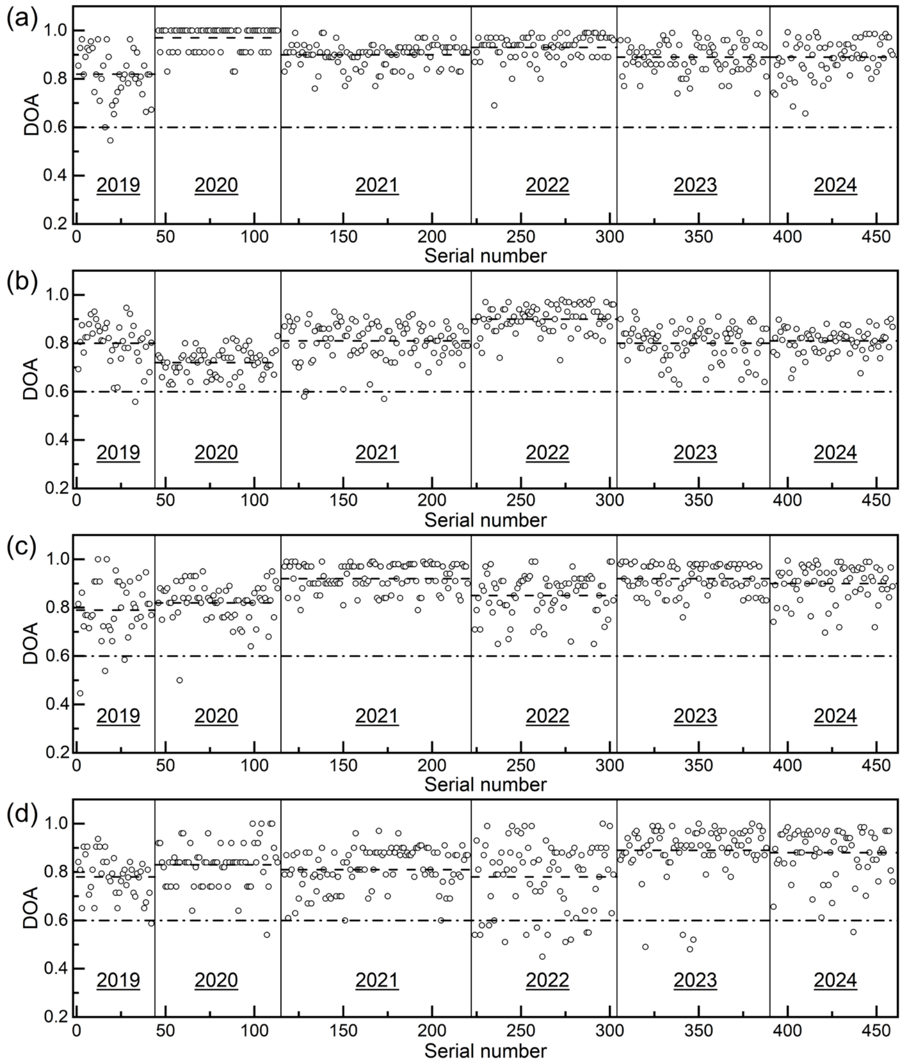


**Fig. 6.** The scatter plots of each student's DOA for all course objectives in different teaching years (a: Objective 1, b: Objective 2, c: Objective 3, d: Objective 4).

# 4 Conclusion

The course "Chemical Environmental Protection and Cleaner Production" in CET major at Jianghan University was selected as the research object in this work. The teaching process from 2019 to 2024 was tracked, and various learning effectiveness evaluation data such as student scores, grade distribution, and DOA of course objectives were collected, calculated and analyzed. Analysis results show that: (1) The passing rate has been excellent, and the proportion of students achieving good and excellent grades in the overall assessment has been high in the past 6 years. The overall teaching and learning effectiveness of the course was good. (2) In the four assessment sections of this course, the final exam grades were relatively poor, and further reinforcement is needed in the subsequent teaching process in the future. (3) The achievement status of course objectives has steadily improved with the continuous improvement mechanism of CEEA. CEEA can not only ensure the teaching and learning effectiveness of a specific course, but also improve students' comprehensive abilities.

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