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# Rain Classroom facilitates the teaching reform and practice of Chemical Engineering Principles

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**Abstract**
Traditional teaching methods for the core chemical engineering course "Chemical Engineering Principles" often suffer from low student engagement, a disconnect between theory and practice, and a singular assessment approach. To address these challenges, this study integrated the smart teaching tool "Rain Classroom" into the course, establishing a student-centered, data-driven blended learning model. A comparative study was conducted between a control group (Class of 2020, traditional teaching) and experimental groups (Classes of 2021 & 2022, Rain Classroom teaching). Results demonstrated a significant optimization in grade distribution within the experimental groups, shifting from a "pyramid" shape to an ideal "spindle" shape. Specifically, the proportion of high-scoring students (≥80 points) in the 2021 cohort surged to 48.2%, compared to 21.4% in the control group, while the low-scoring segment (≤69 points) plummeted from 55.4% to 26.8%. The study concludes that Rain Classroom, by delivering visualized pre-class materials, enabling anonymous real-time interaction, embedding engineering case studies, and reforming the assessment system, effectively stimulates learning motivation, enhances classroom efficiency, and cultivates students' engineering thinking and problem-solving skills. This practice offers a viable and effective pathway for reforming teaching methodologies in core chemical engineering courses.

**Keywords:** Rain Classroom, Chemical Engineering Principles, teaching reform, problem-solving skills

## Introduction

Chemical Engineering Principles, as a core fundamental course for chemical engineering majors, builds upon higher mathematics, physics, physical chemistry, and computational techniques. It applies universal laws of natural science to solve engineering problems, cultivating students' ability to analyze and address engineering challenges. Serving as a bridge connecting foundational knowledge to engineering applications, this course emphasizes practical engineering experience, manifested through multiple influencing factors, constraints, and extensive empirical formulas and data in unit operations [1, 2]. These characteristics pose significant challenges to both teaching and learning.

In recent years, with the development of computer and information technologies, various information-based teaching tools have emerged. "Rain Classroom," an intelligent teaching tool based on WeChat and PowerPoint, provides a new support platform for traditional classroom teaching. With features such as personalization, data-driven insights, and intelligent functionality, it offers innovative approaches for enhancing the teaching of Chemical Engineering Principles.

## Current Status and Issues in Traditional Teaching of Chemical Engineering Principles

### 1. Passive and Ineffective Pre-class Preparation

In traditional teaching, students primarily rely on textbooks for previewing course content. However, unit operations such as absorption processes and distillation principles are often abstract and difficult to comprehend. Additionally, engineering case studies in textbooks tend to be outdated. Students often resort to rote memorization of formulas without understanding their applicability and limitations, hindering the development of engineering thinking and practical problem-solving skills [3]. Furthermore, misalignment between textbook content and lecture pacing reduces the effectiveness of pre-class preparation.

### 2. Lack of Interaction and Timely Feedback

In large-class settings, limited teaching hours make it difficult for instructors to address individual student needs. Classroom discussions often involve only a small number of students, leaving the majority as passive listeners. When students encounter difficulties during lectures, they seldom have the opportunity to seek immediate clarification. Limited teacher-student interaction outside the classroom leads to accumulated knowledge gaps, adversely affecting subsequent learning.

### 3. Disconnect Between Theory and Practice

Traditional teaching overemphasizes theoretical knowledge, with students passively receiving information about unit operations such as fluid transport, heat transfer, and absorption. This approach neglects practical aspects such as multi-factor coupling, non-ideality, and economic considerations in industrial applications [4, 5]. For example, while students may memorize the head formula of centrifugal pumps, they often struggle to understand the comprehensive impact of valve adjustments on flow rate and energy consumption in piping systems. Similarly, understanding the trade-offs between reflux ratio adjustments and product purity in distillation columns remains challenging. This theory-heavy approach fails to cultivate essential engineering thinking.

**4. Rigid Assessment Methods**

Traditional evaluation relies heavily on closed-book final exams, emphasizing memorization and computational skills rather than comprehensive understanding. This approach discourages critical thinking and innovation, failing to reflect students' practical abilities and holistic development.

## Application of Rain Classroom in Chemical Engineering Principles Teaching

Rain Classroom is an intelligent teaching tool developed through the collaboration of Tsinghua University's Online Education Office and XuetangX. Its core design philosophy centers on "connecting teachers and students while enabling intelligent instruction." Characterized by its user-friendliness, comprehensive coverage of the entire teaching process, panoramic data recording capabilities, and flexible support for blended learning models [6, 7], its application in the Chemical Engineering Principles curriculum holds significant potential for addressing the aforementioned challenges in traditional teaching methods.

**1. Enhancing Pre-class Engagement**

Instead of assigning generic preview tasks, instructors use Rain Classroom to share multimedia resources such as narrated PowerPoint slides, animated videos demonstrating fluid dynamics and equipment structures, and real-world factory footage. These resources transform abstract concepts into engaging content, stimulating students' interest and reducing cognitive load.

**2. Facilitating Real-Time Interaction and Feedback**

"Confused" Button - Anonymous Silent Feedback. This represents a revolutionary feature of Rain Classroom. For instance, when an instructor explains the "physical meaning of the Reynolds number," any student who fails to grasp the concept can simply click the "Confused" button on the PowerPoint slide without raising their hand. The teacher's interface then displays the number of confused students in real-time, allowing for immediate adjustment of the teaching pace and depth, followed by re-explanation of difficult points. This achieves comprehensive, anonymous, and real-time feedback—something previously unattainable in traditional classrooms.

**Bullet-Chat Interaction:** Stimulating Active Thinking. When discussing topics like "how to improve the separation efficiency of a distillation column," the instructor can activate the bullet-chat function. Students can freely share ideas such as "increase the reflux ratio" or "adjust the feed location." As these suggestions flow across the screen, the classroom atmosphere instantly becomes more dynamic. This facilitates synchronized one-to-many and many-to-many interactions, breaking the limitations of the traditional "instructor asks, few students answer" model [8].

**Timed Quizzes:** Whole-Class Knowledge Assessment. After covering a key concept (e.g., "cavitation in centrifugal pumps"), a multiple-choice question is instantly pushed to students, who must answer within one minute. The instructor can immediately view the overall accuracy rate. If the rate falls below 60%, it indicates that most students haven’t mastered the concept, necessitating further explanation. If it exceeds 90%, the class can proceed quickly. This enables data-driven, instant teaching decisions, shifting the instructional approach from "intuition-based" to "evidence-based."

**3. Integrating Engineering Case Studies**

In-class Case Discussion: The instructor can push a simplified engineering case (e.g., "Heat exchanger fouling in a chemical plant leads to efficiency decline—propose solutions") to students. Working in groups, students discuss the problem and submit their analytical approaches and conclusions via Rain Classroom's submission or open-ended question function. The instructor can then project representative answers for detailed explanation and commentary.

Virtual Simulation Integration. The instructor can share the interface or results of chemical process simulation software (e.g., Aspen Plus) through Rain Classroom, guiding students to observe how parameter changes (e.g., the impact of feed temperature on the temperature distribution across distillation column trays) affect the entire system.

Post-class Extension. By sharing resources such as real-world factory photos, equipment diagrams, and cutting-edge research papers related to the course content, students are guided to connect classroom theory with the authentic, complex world of engineering.

**4. Comprehensive Evaluation System**

Rain Classroom automates the assessment of pre-class preparation, in-class participation, and regular quizzes, accounting for a significant portion (e.g., 20%) of the final grade. This diversified evaluation values learning processes and progress, promoting sustained engagement and holistic development.

## Teaching Effectiveness Evaluation

Since 2021, Rain Classroom has been implemented in teaching Chemical Engineering Principles. A comparative study involved students from 2022 (traditional teaching) and 2023–2024 (Rain Classroom-based teaching). The students majored in Applied Chemistry. The distribution of students under different teaching methods is shown in Table 1.

**Table 1:** Student Information Corresponding to Different Teaching Methods

| Grade | Number of students | Major | Control class | Experimental class |
|---|---|---|---|---|
| 2020 | 56 | Applied Chemistry | √ | |
| 2021 | 56 | Applied Chemistry | | √ |
| 2022 | 51 | Applied Chemistry | | √ |

## 1. Academic Performance

A comparison between the experimental classes (2021, 2022) and the control class (2020) is shown in Figure 1.

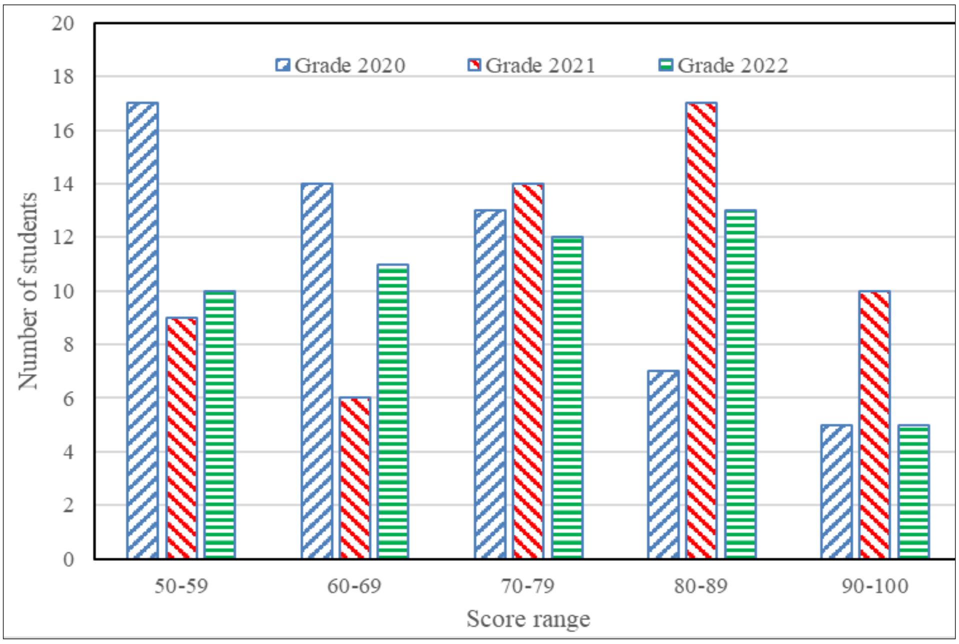


**Fig 1:** Comparison of Grade Distribution between Control and Experimental Classes

As shown in Figure 1, the grade distribution of the control class (2020) is "pyramid-shaped" (most students in lower score ranges), indicating significant academic challenges. In contrast, the distribution for the experimental classes (2021, 2022) shifts towards an ideal "spindle-shaped" or healthier "cone-shaped" pattern, with the middle and high-score segments becoming dominant.

Regarding high and low scorers, the implementation of Rain Classroom led to a significant increase in high-scoring students (≥80 points). The control class (2020) had only 12 high-scoring students (21.4%), while the experimental class (2021) had 27 (48.2%), forming a prominent high-achieving group. The 2022 experimental class had 18 high-scoring students (35.3%), which, although fewer than in 2021, was still higher than the control class. Concurrently, the number of low-scoring students (≤69 points) decreased sharply. The control class (2020) had 31 low-scoring students (55.4%), meaning over half performed poorly. This number dropped significantly to 15 students (26.8%) in the 2021 experimental class—less than half of the control group. The 2022 experimental class had 21 low-scoring students (41.2%), which, despite being higher than in 2021, remained significantly better than the control class. These results indicate that Rain Classroom not only effectively supported students with weaker foundations, reducing failure and low-score rates, but also stimulated the potential of average and higher-achieving students, thereby improving overall learning outcomes.

## 2. Teaching Model Transformation

### 2.1 Shift in Classroom Interaction Patterns

Classroom observations and video analyses indicate a significant increase in student engagement ("heads-up" rate) and a livelier atmosphere. Features like bullet chats and submission options provide every student with an equal opportunity to express themselves, breaking the pattern where only a few active students participate in traditional classrooms.

### 2.2 Scientization of Teaching Decisions

Teaching transitions from being "experience-driven" to "data-driven." Instructors no longer rely on intuition to gauge student understanding but make real-time adjustments to teaching pace and depth based on data from in-class exercises and the "Not Understood" button, achieving precise teaching.

### 2.3 Immediacy and Personalization of Feedback and Tutoring

For students, immediate feedback on exercises and anonymous expression of doubts allow students to resolve issues promptly, reducing the accumulation of learning deficits.

For instructors, data reports enable quick identification of struggling students, allowing for personalized tutoring via Rain Classroom's "private message" feature, thus normalizing formative assessment.

## Conclusion

The application of the Rain Classroom smart teaching tool effectively addresses the core challenges in the traditional teaching of Chemical Engineering Principles. By enriching teaching resources, enhancing classroom interaction, embedding engineering practice, and reforming assessment methods, it significantly improves students' learning outcomes. It promotes the transformation of the teaching model towards a student-centered, data-driven approach, strongly supporting the teaching reform of the Chemical Engineering Principles course and playing a positive role in cultivating students' engineering thinking and complex problem-solving abilities.

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