

**Methodology Article**

# Exploration and Practice of Flipped Class Mode for “Unit Operation of Mixing” Lecture Under the Outcome Based Education Concept

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**Abstract:** Based on outcome and education concept, for the training objective, the flipped class is applied to the teaching process of mixing unit operation through the implementation of teaching task list, teaching video, teaching courseware, classroom teaching, teaching summary and other measures, which builds students' proactive learning abilities and arouses the learning interest of students in mixing unit operation. The course scoring structure is diversified, covering the preview before class, discussion in class, homework exercises and extended applications after class. Through the investigation and analysis of the teaching situation, we find that most students recognize the role transformation between teaching and learning, are able to adapt to the flipped class mode and satisfied with the teaching effectiveness. Meanwhile, students think that the flipped class mode can increase students' opportunities in independent thinking and problem solving, which is of great benefit to improve their learning ability. The exploration and practice of flipped class mode for “Unit operation of mixing” lecture replaces the “cramming education” teaching style and motivates students creativity. The statistics of survey data on teaching effectiveness shows a high percentage of acceptance, recognition and perception on the new flipped class mode. The successful implementation of the flipped class mode on the specific lecture also provides insights in other lectures in “Principles of Chemical Engineering”.

**Keywords:** Flipped Class, Principles of Chemical Engineering, Mixing

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## 1. Introduction

It is widely noticed that education has entered the new age of “Internet+” and “Big Data”. The approach of acquiring knowledge and the communication mode have been changed correspondingly. At the same time, the education concept and teaching method have been gradually improved with the popularization and development of education information. Traditional education concept and classroom teaching mode, function and orientation of teachers, and the scope and depth of instructional knowledge are facing unprecedented challenges. Outcome based education (OBE) is an education concept orientated by the learning outcomes of student. According to the concept of OBE, the goal of the design and

implementation of teaching is to learn outcomes of students after the education process, which emphasizes the integrated teaching mode focusing on questions and student integration.

OBE concept has to fulfill following requirements: (1) specific learning outcomes; (2) arrangement and implementation of the teaching activities according to the diploma requirements; (3) evaluation of the student achievement. According to the guidelines of engineering degrees by Ministry of Education of China (12 merits in total) and training objectives from East China University of Science and Technology (ECUST), we worked out teaching matrix for course “Principles of chemical engineering”. This matrix has been approved by faculty and the teaching commission (see Table 1).

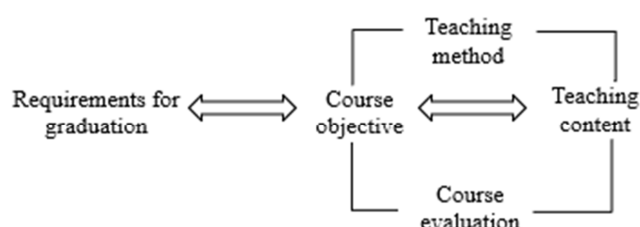
**Table 1.** Support rectangle of the corresponding relation between the requirements of engineering majors and the courses of the principles of chemical engineering.

Index requirements	(1) Engineering knowledge	(2) Problem analysis	(3) Design and develop solutions	(4) Research	(5) Use of modern appliances	(6) Engineering and society
Principles of chemical engineering	H	M	H	M		

*Table 1. Continue.*

Index requirements	(7) Environment and sustainable development	(8) Professional norm	(9) Personal and team	(10) Communication	(11) Project management	(12) Lifelong learning
Principles of chemical engineering						

We constructed the closed-loop system (as shown in Figure 1) after the determination of the forementioned matrix. The system constitutes the logical supporting relationship among the requirements of graduation, course objective and teaching contents.

**Figure 1.** Logical supporting relationship among the requirements for graduation, course objectives and teaching contents.

According to this logical relationship, teachers of “Principles of Chemical Engineering” would think about the content of the course, teaching philosophy, teaching evaluation, and finally the way to keep improving the teaching. Following these considerations, teachers will first define the teaching theme, remodel the course design. Second, the teachers will reorganize the knowledge points, refine the methodology related to engineering problems and solve the problem how to teach the course. Third, teachers will evaluate the teaching by both faculty evaluation and student assessment. At last, according to the result of student assessment, teachers will quantitatively analyze the achievement of training objectives and propose the strategy of keeping improving teaching quality.

The flipped class is a new-type teaching mode oriented by students [1-3]. It guarantees the achievement of teaching goal, and helps the teachers practice the mission how to teach. The flipped class can stimulate the learning interest of students and effectively improve the teaching efficiency [4-6]. The flipped class teaching mode has been investigated in different aspects focusing on methodology [7-8], target audience [9-10] and a variety of subjects [11]. In this paper, we apply the flipped mode to the lecture of “Operation of mixing unit”.

Mixing is one of the important unit operations widely used in chemical industry, which enables the mixing of homogeneous liquid and the dispersion of non-homogeneous liquid. The lecture of “Unit operation of mixing” is not included in the major of chemical engineering in most universities in China. In contrast, the lecture is included in the course of the “Principles of chemical engineering” in East China University of Science and Technology. Through the learning process, students will learn the mechanism of mixing process, handle solving the engineering problem involved in mixing process and enhance the creativity.

The unit operation of mixing involves many types of impellers that hinders the students’ passion to learn. Meanwhile, the calculation of mixing power and step-by-step magnifying process are obscure to some extent, making it difficult for students to understand. To seek a high teaching quality, we actively applied the “flipped class” mode to the course of “Unit operation of mixing” and obtained satisfying outcome.

## 2. Design of Flipped Class Teaching Mode

The lecture of unit operation of mixing is rich in content. At the beginning of learning, some students may not understand the two basic concepts of “bulk flow” and “powerful shear” existing in the mixers. Some other students find it difficult to understand the “mixing power loss”, “diversity of stirring blade types” and “complexity of scaling-up criterion”. Students think that the content is relatively disconnected i.e. there is little correlation among different concepts. In a traditional lecture, lecturers usually teach the content from the aspects of “mechanism of mixing dispersion” or “qualitative analysis of mixer and mixing mechanism”. However, students do not have specific knowledge about the stirring blade and will find it obscure to understand. Based on these actual facts, we explored and applied the flipped class teaching mode, covering preview before class, classroom teaching and after-class expansion [1, 12]. The teaching content and training objectives are systematically listed in Table 2.

**Table 2.** Relationship of mixing unit operation, training objective, support strength and teaching contents.

Training objectives	Supporting strength	Teaching content
Engineering knowledge (1)	H	Typical industrial mixing problem; purpose and method of mixing
Problem analysis (2)	M	Measurement of the mixing effect (standard deviation of uniformity, division size and strength); mixing mechanism

Training objectives	Supporting strength	Teaching content
Solution developments (3)	H	stirring device, common type, stirring blade and other components of stirring blade; mixing power;
Research (4)	M	Problem to be solved when the mixer experience is amplified; knowledge of other mixing equipment.

### *Preview Before Class*

The course of the “principles of chemical engineering” in ECUST is a state-level fine-quality course. One of the teaching reform measures of teaching team is to send study materials such as syllabus, courseware, teaching video and learning task list to students through the network education platform built by the university and a third-party company before the class to meet the online learning requirement. The teaching video, usually 10 to 15 minutes, is made by the lecturer of the team in the third party company in professional studios. The content of the teaching video includes the key points and difficult points especially in unit structures that students do not know in daily life, principle and calculation of each unit operation. The teaching video demonstrates students the content of equipment structure and the phenomenon appeared in technical application, making it convenient for students to understand. Meanwhile, students will gain an intuitive understanding about the principle and unit operation before entering classroom, which makes the learning more interesting. For example, the videos can vividly illustrate the structure of stirring blade and explain the mechanism of mixing and dispersion, the method to avoid “swirling (circling motion)” and the power consumption of stirring blade. In addition, students can watch and learn the teaching videos repeatedly, which effectively prevents the drawback of missing knowledge point due to time limitation in traditional teaching process. In other words, students overcome the difficulty that they cannot learn profoundly by watching the teaching video repeatedly.

The teaching video contains certain of questions for student to think and solve during the learning process. For example, these questions could be how to measure the mixing effect; how to measure the dispersion effect; what is the difference between these two measurement methods; what is the cause of these two measurement methods. Students can answer the questions on network education platform directly and if they cannot answer the questions correctly, students can immediately look back the video until they understand it totally. The digital network education platform will record the watching time to inspect the learning progress, which provides hints for classroom teaching. The platform scores the performance of each student according to the completion and quality of the preview process before class.

### *Classroom Teaching*

Students learn the course teaching video online and can obtain most of the teaching contents. In contrast, the classroom teaching takes offline. At first, teachers check the pre-class learning performance and ask students questions to urge the preview learning and ensure the quality. The performance that students answer the questions is one of merits of scoring. Then the lecturer comments the answers of students and the accomplishment of learning tasks list.

The lecturer then focuses on explaining the key points and difficult points and enhance the understanding for students. For those knowledge which easily causes misunderstanding and confusion, the lecturer has to design questions for students to discuss. The discussion process has to be controlled within certain time, usually 6 to 8 minutes. For example, these “confusing” concepts could be the comparison of “mixing” and “dispersion”; what is the effect of stirring blade when providing energy to the fluid (or suspension liquid, various dispersions); is the dispersion of suspension liquid or gas caused by the direct “strike” of blade? In the teaching of mixer power distribution, we can also set questions such as “why the larger consumed energy usually provides a better mixing efficiency” and “how to ensure the correct and reasonable use of the energy in the mixing process”. Students discuss in groups and the lecturer actively participates in the discussion to supervise and guide the discussion. At last, the lecturer delivers comments and summaries. It is noteworthy that classroom teaching is an organic combination of traditional classroom teaching and flipped class teaching, which enhances the student’s awareness of proactive learning in courses. It eases the process for teachers to grasp students’ performance in understanding knowledge point so as to provide more customized and interactive classroom teaching.

### *After-Class Homework and Extended Application*

In order to help students consolidate the knowledge, the lecturer assigns homework or extended application to students after class according to the content. The homework can be the exercises from textbook, or the self-test questions. The extended application is more flexible and not subject to certain patterns. It could be the problem that students encounter in the learning which allows students to learn the knowledge from “perception” to “internalization”. Typical extended applications could be: why is the mixer of the household washing machine installed off center; why does a homogenizer usually operate at a high speed; what is the difference between the mixing process of acid/alkali-aqueous solution and the mixing process of gas-liquid reaction process. Through these extended applications, students can actively think and discuss the breakage, dispersion, coagulation and stratification process. Students eventually complete their homework about design of mixing scheme and submit it to the teacher. The accomplishment of homework and extended application is also one of the evaluation merits of the final score. The course “Principles of chemical engineering” has strong applicability. Through the knowledge extension after class, students would realize that the knowledge they learn is useful and can solve actual engineering problems in daily life or chemical industry. Undoubtedly, it enhances students’ interest and motivation in learning.

### 3. Implementation of Flipped Class Teaching Mode

The implementation of flipped class teaching mode covers two modes (online and offline) and three phases (preview listed in Table 3 (taking mixing unit operation as the case))

before class, classroom teaching and after-class homework) [13-14]. The flipped class teaching involves interactions between students and teachers [15]. The implementation process is shown in Figure 2. The design of teaching content is

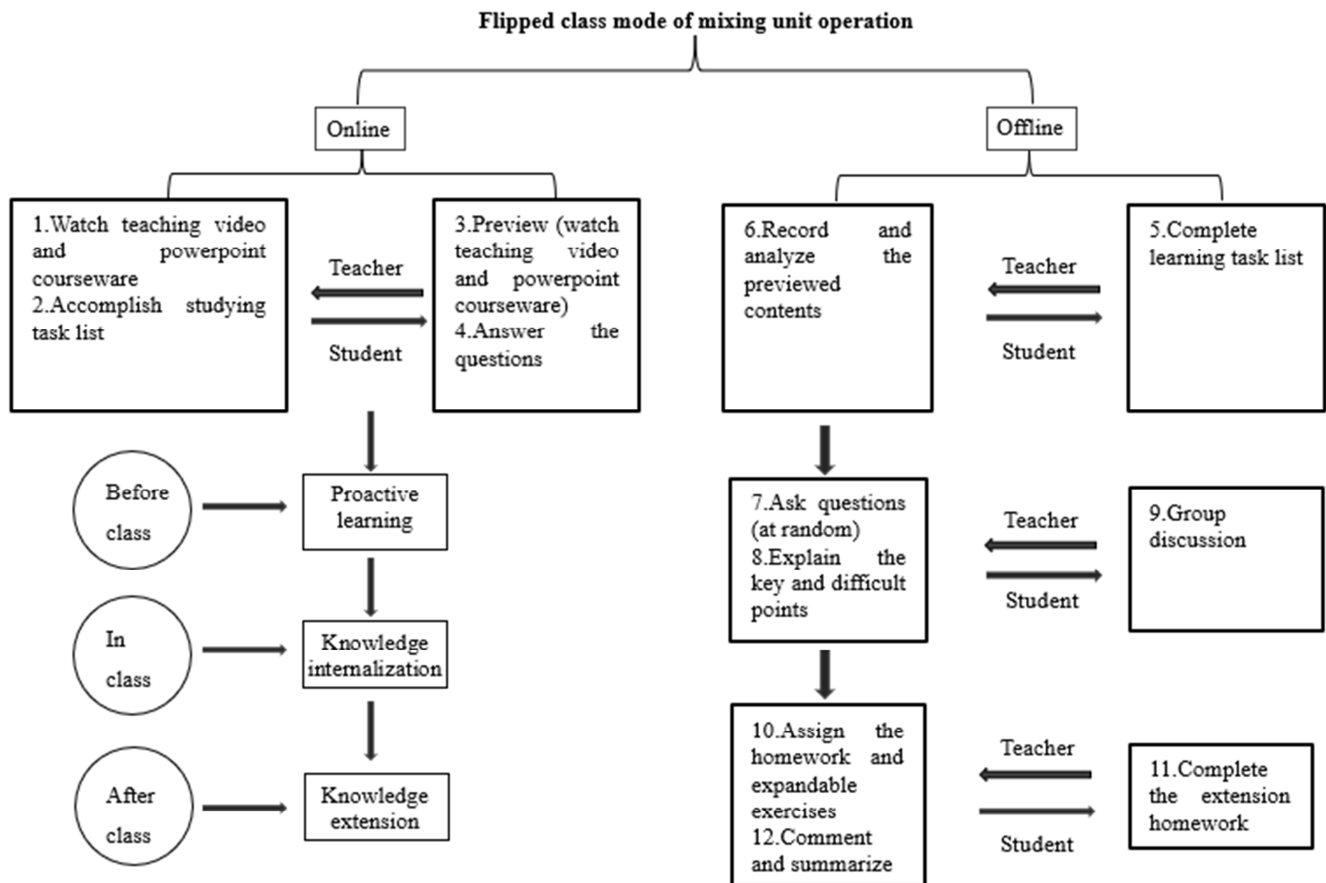


Figure 2. Implementation process of flipped class teaching mode of mixing unit operation.

Table 3. Design of teaching content of "unit operation of mixing" using flipped class mode.

Teaching steps	Items in teaching process	Specific content of learning activities of students
Before class	1 Self study 2 Answer the questions	Watch teaching video and courseware
In class	Group discussion	1 What is the purpose of the mixing? What are the types of mixers? Which situations are they suitable for? 2 How to measure the mixing effect? How to measure the dispersion effect? What are the requirements of division size on mixer? 3 What two functions should the mixer have? How to ensure the proper implementation of these two functions? 4 What are the dispersion mechanisms of the homogeneous liquid, non-homogeneous system, solid particles, respectively? How to determine the critical impeller speed? What are the engineering approaches to improve the mixing effect? 5 What is the purpose of the distribution of the mixer power? How to ensure a reasonable distribution? What is the scaling-up criterion for mixers?
After class	1 Complete exercises and self-test exercises 2 Complete extended applications Teaching evaluation	Why is the mixer of the household washing machine installed off center? Why does a homogenizer operate at a high speed? What is the difference between the mixing process in the acid/alkali-aqueous solution and the mixing process of gas-liquid reaction process? Acquire state-of-art of high-efficiency mixing equipment through the Internet or literature. Summarize the teaching outcome with the comprehensive assessment

## 4. Teaching Evaluation

By applying the teaching mode of flipped class, the grading structure is composed of non-exam performance (50%) and final exam grade (50%). The non-exam performance consists of three parts: 1) accomplishment of the task of the proactive learning in teaching video (online), 2) lecture attendance and 3) the accomplishment of offline homework and extended applications. The non-exam performance portion enables a diversified structure and enhance students' motivation in self-study during the course. The final exam is completed in close-book format, which is similar to the traditional teaching.

## 5. Teaching Effectiveness

The role of teachers and students has fipped in the new mode. Regarding to this change, the students' acceptance of the flipped class mode is investigated via survey, as shown in Figure 3. Figure 3 illustrates the statistics of the acceptance degree in flipped class teaching model. The positive result shows that 58% of total students like it very much, and 39% like it moderately, while the remaining 3% dislike it moderately.

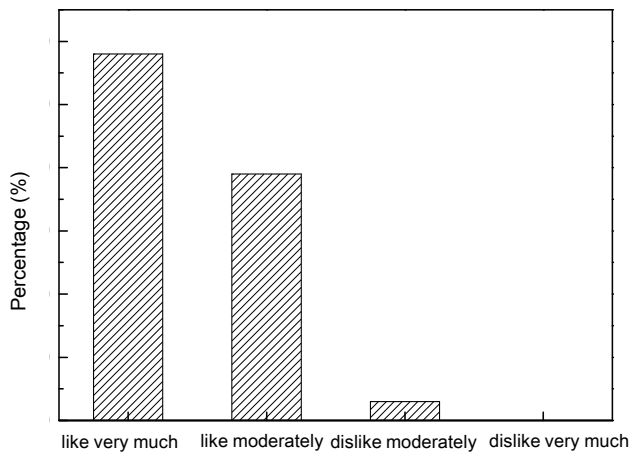


Figure 3. Acceptance in flipped class teaching mode.

The purpose of implementing flipped class teaching is to ensure the achievement of teaching objectives. In addition to considering students' feelings, we further investigate the teaching effectiveness. Table 4 is a survey of the recognition degree of teaching effectiveness. It is found that the vast majority of students think that the effectiveness of new flipped class teaching mode is excellent, supported specifically by the recognition rate in satisfaction with i) role switch in teaching and learning; ii) classroom atmosphere; and iii) knowledge mastering.

Table 4. Recognition degree of teaching effectiveness.

Items	Recognition rate
Satisfaction with role switch in teaching and learning	98%
Satisfaction with classroom atmosphere	99%
Satisfaction with knowledge mastering	93%

Whether a new teaching mode can be successfully adopted

depends on the perception of the students. For this reason, we also carried out a survey on perception of learning effect, as shown in Table 5.

Table 5. Perception of learning effect.

Items	Percentage
Increase opportunities for independent thinking and problem solving	98%
Improve self-learning ability	99%
Gain a deep understanding in knowledge	91%

## 6. Conclusions

Based on the training objectives, we developed the course syllabus and teaching contents by applying the flipped class to “mixing unit operation”. The new teaching mode has completely replaced the “cramming education” teaching, and fully motivated student’s interest, improved student’s ability in solving engineering problems and innovation. The flipped class mode demonstrates a diversified scoring structure that covers the non-exam performance of student through the preview before class, discussion in class, homework exercises and extended applications after class.

The survey result on teaching effectiveness shows that the overwhelming majority of students accept and recognize the new flipped class mode and they demonstrate a high perception percentage of learning effect. The practice of the flipped class mode on the lecture “Unit operation of mixing” opens a new window for other lectures of the course “Principles of Chemical Engineering”.

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