# Research on Hybrid Teaching of Computer Composition Principle Based on Engineering Education Certification

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**Abstract.** The paper analyzes the current teaching situation of the course "Computer Composition Principles" from the perspective of "student-centered, output-oriented and continuous improvement", and designs the "1-3-2-1" hybrid teaching organization model based on the engineering education accreditation. The organization mode is based on the digital course resources of Super Star MOOC, interactive communication on the online platform, and problem-oriented teaching activities. This model is conducive to cultivating students' independent learning ability, enabling them to deepen their understanding and mastery of the computer composition course, adopting diversified assessment and strengthening process control, so as to improve teaching quality and achieve the course teaching objectives.

**Keywords:** Principles of Computer Composition · Engineering Education Certification · Blended Teaching · Independent Learning

## 1 Introduction

Engineering education professional certification is an internationally accepted quality assurance system for engineering education [1]. China officially joined the Washington Agreement on Mutual Recognition of Engineering Education Degrees in June 2016, aiming to improve the quality of engineering professional talents cultivation in China and promote international mutual recognition of engineering degrees through engineering education professional certification [2]. The OBE (Outcome-based Education) concept of "student-centered, output-oriented and continuous improvement" [3] is the development direction of the new engineering education reform in the new era, which is crucial to improve the quality of engineering education in China.

As a compulsory professional foundation course for computer engineering students, "Principles of Computer Composition" plays an important role in the teaching and training program of computer engineering majors [4]. The goal of the course is to tell the working principle of computer from the perspective of hardware, to understand and master the working principle of the main functional components of computer, the frontier development of computer hardware technology and the working process of computer hardware through the study of five major components of computer, and finally


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to establish the concept of the whole machine. The course also aims to cultivate the development ability to combine mathematics and natural science knowledge to solve complex problems in computer engineering and other related fields.

## 2 Analysis of Teaching Status

The course "Principles of Computer Composition" is offered in the first semester of sophomore year, during which students have already learned advanced programming language and have a certain understanding of computer software, but they still lack the knowledge of computer hardware, and their enthusiasm for learning hardware has decreased compared with software.

The course "Principles of Computer Composition", which is taught by Prof. Tang Shuofei, is based on the Von Neumann type of computer, including controller, operator, memory, input and output devices [5]. This course introduces the fundamental features of computers, consisting of the overview, bus system, memory system, input and output systems, data representation and operation, instruction system, and CPU function and design. This course covers numerous complicated theories, which is too difficult and abstract for students to understand. The high degree of internal integration in the current computers makes it even harder for students to imagine and visualize the internal structure and the work process of computers. With the feeling that the in-depth knowledge of this course is not beneficial for future job hunting, some students only have limited understanding of this course at the end. As a result, some students rely on rote memorization to cope with exams with no deep comprehension of fundamentals at the end of the course.

## 3 Hybrid Teaching Organization Based on Engineering Education Accreditation

According to the characteristics of the course "Computer Composition Principle", the analysis of students' learning situation and the teaching concept of "student-centered, result-oriented and continuous improvement" [6] in engineering education accreditation, the course team researched this course, clarified the teaching objectives of the course, improved the syllabus and redesigned the content. The new design of the content is problem-oriented and adopts the "1-3-2-1" hybrid teaching organization format.

The first "1" refers to a main line that the whole course is based on binary. This course forms an organic whole for the concept of the whole machine through the execution of instructions, the bus, data representation and operation, instruction system, memory, IO devices and CPU data transfer control mode and CPU organic connection. It can help students to build their own knowledge system. "3" refers to the classroom teaching organization form using the three-step hybrid teaching organization form, which contains independent learning before class, internalizing knowledge during class and consolidating knowledge feedback after class. The hybrid teaching organization form is shown in Fig. 1. The "2" refers to the adoption of two assessment methods for achieving engineering education certification. The two methods are formative assessment and

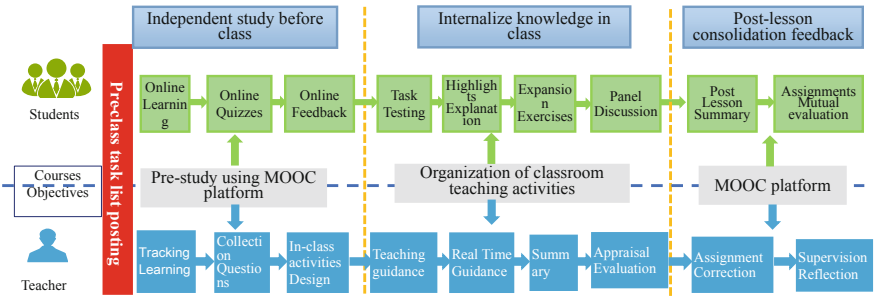



**Fig. 1.** Hybrid teaching organization based on engineering education accreditation

comprehensive assessment in the final examination. The last "1" refers to the final goal of improving students' enthusiasm for learning, thus improving teaching quality and achieving the engineering education accreditation standards.

### 3.1 Pre-course Introduction Stage

The course team designed the pre-course task list according to Bloom's Taxonomy of Educational Objectives [7] and the course teaching objectives. The content is decomposed from shallow to deep. The detailed learning objectives are formulated. The assignments varies from concept recognition and memory, description and understanding, application, analysis, evaluation to innovation. According to the learning objectives, 5–18 min of teaching videos were recorded and corresponding teaching materials were provided. Teachers put the resource network teaching platform "Super Star MOOC" on the platform, informed students of the pre-course pre-reading contents 4 to 8 days in advance, and designed 5–12 questions quizzes according to the learning objectives to test students. The teacher will track and collect students' learning information. The learning information and the feedback from students are then used to design classroom activities. The design of the pre-task list is shown in Table 1, which is based on the bus communication control of bus system. The feedback of students on pre-class task list learning is shown in Fig. 2.

Students will be divided into groups of 4–6 students according to the principle of "homogeneous pairing, heterogeneous grouping, and parallel groups" at the beginning of the school year. They will carry out pre-study and group discussion on the MOOC platform through the pre-study task list, and find problems and ask questions according to the pre-study. They will also have to complete the corresponding quizzes, summarize the knowledge points and draw mind maps, so as to extend the learning from inside to outside the classroom and realize the organic combination of classroom teaching and MOOC teaching.

**Table 1.** Bus system - bus control task list design

| Project name | Contents |
|---|---|
| Learning content | Bus communication control: bus cycle, synchronous communication, asynchronous communication, semi-synchronous communication, separated communication.<br>Key points: transmission speed (baud rate) of asynchronous communication |
| Learning Objectives | 1. Be able to remember the way of bus communication control.<br>2. Be able to distinguish and analyze the bus communication control methods.<br>3. Be able to understand the stages of the bus cycle and distinguish the interlocking mechanisms of non-interlocking, semi-interlocking and full interlocking<br>4. Be able to calculate the baud rate and bit rate of asynchronous communication. |
| Pre-Lesson Task Design | (1) Watch Chapter 2.12 to 2.18 of the MOOC platform Principles of Computer Composition.<br>(2) Be able to answer the questions: what is bus optimization, what are the different ways of bus optimization, and what are the characteristics of each.<br>(3) Be able to answer how many phases of bus transmission cycle, what each phase does, and the characteristics of synchronous communication and asynchronous communication.<br>(4) Be able to answer the characteristics of semi-synchronous communication and separated communication, and calculate the transmission rate of asynchronous communication (calculation of baud rate and bit rate).<br>(5) Complete the post-lesson exercise 16. Complete Bus Quiz 2.19 according to time requirements.<br>(6) Summarize what you have learned, create a PPT or word document or mind map, and list the other questions for this course. (A 5-min presentation is required for this course. Please truthfully fill in the pre-class learning task sheet.) |

### 3.2 In-Class Internalization Learning Stage

The in-class internalization stage is to exchange and share knowledge, and help students to form and build their own knowledge system. Different methods can be used in the organization of classroom teaching to achieve this goal.

(1) Design 3–5 questions for students' pre-study to test the pre-class tasks and ask them to finish within a limited time. Ask them to explain their ideas, check their pre-study status and find their problems.

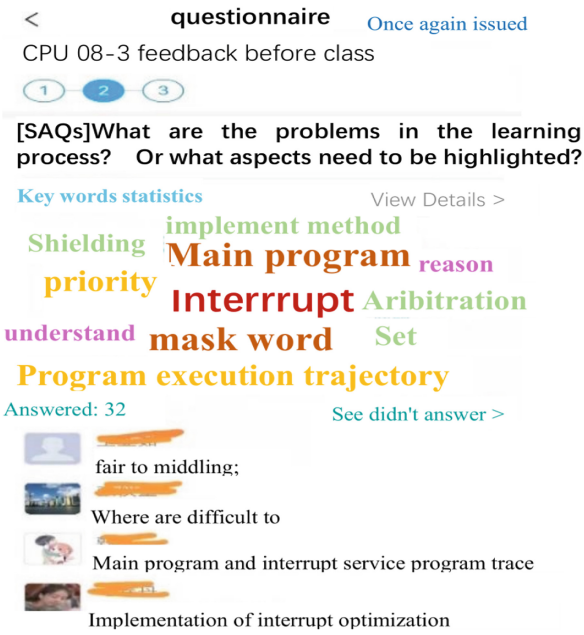



**Fig. 2.** Finish the task list before class

(2) Focus on explanation of the existing problems and students' feedback on the key difficulties. Guide students to solve problems and acquire the knowledge through extended training and other teaching activities.
(3) Problems asked by students can be carried out in the learning pass discussion or questionnaire, and the use of word cloud can help understand the student learning status. For example, for students who have data representation and operations of this chapter, the word cloud can be utilized to understand the students' feedback and know their questions as shown in Fig. 3. Results show that most students mentioned floating point number, and calculation operations, indicating that a longer time should be allocated to help students better understand these topics.
(4) During the lesson, Learning Pass can be used to conduct interactive activities such as in-class questions, quizzes, grading, grouping tasks, and mind map presentations to activate the classroom learning atmosphere, improve students' attention, stimulate learning enthusiasm, and improve teaching effectiveness. The in-class quizzes are shown in Fig. 4.

### 3.3 Post-class Consolidation Stage

Through the learning before and during the class, students improve the mind map and upload it, summarize the problems in the learning process. The teacher issues after-class assignments according to the students' learning. Students then complete these assignments and anonymously review each other's assignments according to the requirements. The peer-graded assignments allow students to think independently, and understand

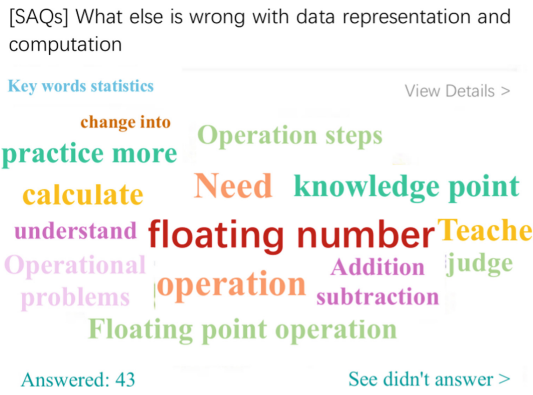



**Fig. 3.** Data representation and arithmetic problems of the survey word cloud statistics

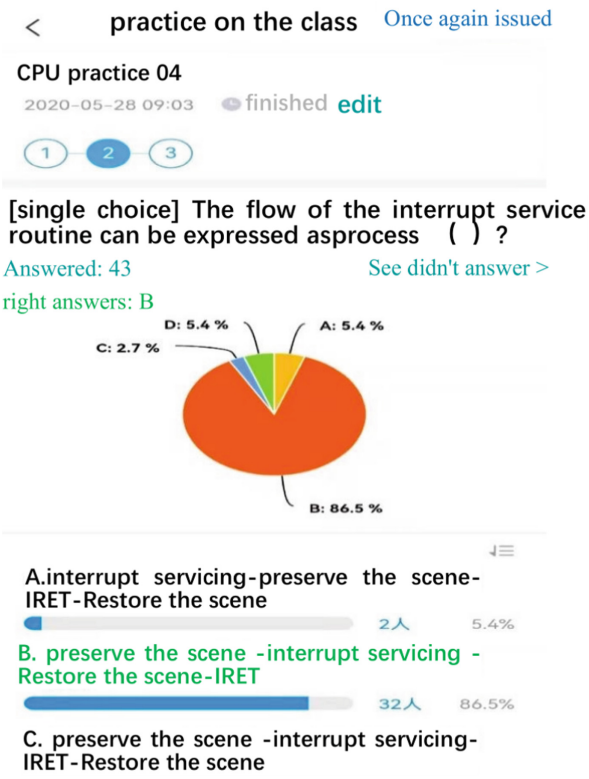
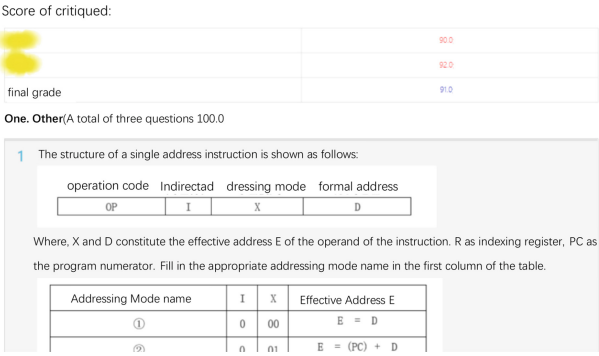



**Fig. 4.** The situation of in-class quizzes


Score of critiqued:

| | |
|---|---|
| [redacted] | 90.0 |
| [redacted] | 92.0 |
| final grade | 91.0 |

**One. Other**(A total of three questions 100.0

1 The structure of a single address instruction is shown as follows:

| operation code | Indirectad | dressing mode | formal address |
|---|---|---|---|
| OP | I | X | D |

Where, X and D constitute the effective address E of the operand of the instruction. R as indexing register, PC as the program numerator. Fill in the appropriate addressing mode name in the first column of the table.

| Addressing Mode name | I | X | Effective Address E |
|---|---|---|---|
| ① | 0 | 00 | E = D |
| ② | 0 | 01 | E = (PC) + D |

**Fig. 5.** Students evaluate each other's homework

the answers of other students, which helps them to identify common problems, master different solutions and deepen their understanding and application of knowledge. Students' mutual evaluation of homework is shown in Fig. 5. The teacher will conduct statistical analysis based on the completion of students' homework, explain or discuss the exercises with high error rate online in time, reflect on the teaching situation in class, consider how to better improve teaching regarding the problems, summarize the feedback from students and further modify the design of teaching activities to achieve continuous improvement of teaching quality.

### 3.4 Teaching Course Assessment Evaluation

Learning assessment is an important part of teaching and learning [8]. According to the ways to achieve the objectives of each course in engineering education accreditation, and the need to evaluate the achievement of each course objective, the corresponding assessment and evaluation methods are determined. The learning assessment evaluation index of the course is divided into process and comprehensive assessment, including not only the traditional examination results, but also the evaluation contents that can reflect students' initiative and enthusiasm, such as work evaluation, collaboration and students' learning attitude [9]. The methods of evaluation can also be diversified, including quizzes, observation, work presentation, self-assessment, mutual evaluation, and grade evaluation method. Students can be evaluated using the learning monitoring data in the SuperStar MOOC platform.

Through the three-step hybrid teaching organization form, all activities of students and teachers have corresponding data records. These data can be used to set diversified assessment standards. The diversified assessment methods is able to evaluate students' learning more comprehensively and diversified, and reflect students' learning more directly and objectively. The first four items in Table 2 are the process assessments, and the last one is the comprehensive assessment.

For the process assessment, the stage assessment of students' knowledge mastery is carried out by using the learning participation and chapter quizzes on the Learning Pass online platform. The classroom activities such as accompanying quizzes, classroom questions, discussions, and group tasks are used to understand students' knowledge

**Table 2.** "Principles of Computer Composition" course examination links and proportion

| Inspection items | Ratio | Appraisal/evaluation rules |
|---|---|---|
| Online classroom performance | 12 | (1) Students' attendance and class participation procedures, problem solving capabilities, and written expression will be assessed.<br>(2) Include grading for various activities such as accompanying quizzes, answering questions, signing in, group tasks, and questionnaires. |
| Assignments | 12 | (1) The main test is the degree of review, understanding and mastery of students' knowledge.<br>(2) Each assignment will be graded separately according to the percentage system, and the final grade will be the average grade of all assignments. |
| Chapter Quiz | 5 | The main test is to assess the students' ability of pre-studying. |
| Discussion | 3 | (1) Students are assessed on their ability to identify, analyze and summarize problems, their ability to retrieve information, and their knowledge of various computer components.<br>(2) The grading is automatically done by the system. |
| Experiment | 8 | (1) The main tests are hands-on practical ability, analytical and inductive design ability, oral and written expression ability, and teamwork ability.<br>(2) Acceptance of each experiment and scoring of students' answers to questions will be conducted.<br>(3) The final grade will be scored by the acceptance score and the experimental report score. |
| Final Exam | 60 | (1) The main test is the students' mastery of course-related knowledge, comprehensive application and the ability to solve complex problems.<br>(2) The questions are composed of multiple choice, short answer, fill-in-the-blank and application analysis questions. |

mastery in real time. The consolidation of learning is carried out after class through homework and other activities. In the classroom teaching activities to implement the whole process of the usual statistical assessment, the formation of process statistics. The statistics of students learning in the classroom activities for the 18-level software outsourcing class in the 2019–2020s semester are shown in Table 3. The results show that most students can complete the required tasks on time. Teachers use these data to regularly investigate and analyze students' learning. Big data technology is employed to analyze students' learning status and optimize course content. The average class score of 84.9 in the final exam shows that the blended teaching organization is conducive to promote the achievement of the course teaching objectives.

**Table 3.** Statistics of students' learning in classroom activities

| Online teaching activities | Frequency | Student Participation | Total Score | Average score |
|---|---|---|---|---|
| Discussion | 19 | 82.6% | | |
| Grouping tasks | 2 | 96.2% | 20 | 17.7 |
| Sign in | 20 | 98% | | |
| Follow-Up Quiz | 43 | 95.3% | 100 | 82.789 |
| Chapter Quiz | 15 | 95.4% | 100 | 86.138 |
| Coursework | 7 | 95.3% | 100 | 88.956 |
| Experiment | 7 | 95.2% | 100 | 91 |
| Questionnaire | 23 | 97.2% | 113 | 90.97 |

## 4 Conclusions

Combined with engineering education accreditation, the MOOC platform and modern teaching methods are used to establish an online teaching platform for computer composition principles, to realize the "1-3-2-1" hybrid teaching organization form of online and offline classroom teaching, to provide students with independent learning conditions, to drive students' ability of problem identification, and problem solving with a problem-centered approach, so as to cultivate students' all-round development of knowledge, ability and quality, and to meet the requirements of engineering education accreditation.

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