International Journal of Multidisciplinary Research and Publications
ISSN (Online): 2581-6187

Quantitative Evaluation of Teaching Effectiveness for Computer Composition Principle in the Background of Engineering Accreditation

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Abstract**—*****The continuous promotion of engineering education requires the cultivation of professional talents to focus on the two-way improvement of students' learning ability and learning effectiveness. The course "Principles of Computer Composition" is taken as the research object in this paper. Firstly, it decomposes the corresponding relationship between the course objectives in the syllabus and the graduation requirements in the professional training plan. Then, it lists the key assessment content and divides the proportion of grades. Finally, it proposes a method for calculating the degree of achievement of the course objectives, and evaluates the teaching effect through quantitative analysis. Practice has shown that quantitative evaluation can accurately locate teaching difficulties, cultivate students' active learning ability, improve learning effectiveness, and provide new ideas for teachers and management departments.*

Keywords**—*****Computer composition principle; Engineering accreditation; Teaching effectiveness; Quantitative evaluation.*

I. INTRODUCTION

The course of Principles of Computer Composition focuses on the overall internal structure of computers, covering data representation, storage hierarchy, instruction system, central processing unit, pipelined parallel processing, and other main contents [1][2][3]. It provides a detailed discussion of computer organizational architecture, working principles, and implementation methods. The education implemented in the past focused on how teachers can teach students well. However, due to the fact that the curriculum involves the underlying hardware of computer systems, the content is relatively abstract and fragmented, and there are problems such as a lack of teaching aids and poor school experimental conditions in daily teaching. Students generally report that learning difficulty is high, and they are unable to accurately grasp the key and difficult points of the curriculum, resulting in unsatisfactory final assessment results; In addition, the course assessment method is relatively single, and the process evaluation and supervision mechanism is insufficient, making it difficult to support its requirements for student ability development. Nowadays, engineering education focuses on how students learn courses well, with a focus on cultivating their ability to solve complex engineering problems. The basic concept of engineering accreditation is "student centered, output oriented, and continuous improvement". It is an important measure to promote the quality of engineering talent training, promote professional development into the fast lane, and build a "first-class specialty"[4][5].

The teaching content of this course echoes the characteristics of complex problems, including the most basic methods of designing computer internal structures, enabling students to establish a theoretical model of the problem through in-depth analysis, and to design simple controller models through modern tools[6]. In this process, it is necessary to combine the principles provided in the teaching content and apply knowledge such as digital logic circuits and hardware descriptions to achieve the basic goal of microprogramming control, which fully reflects the construction process of complex engineering.

TABLE I. Basic information of the principles of computer composition

Course name	Principles of computer composition
Course No.	18MT1260
Total hours	54
Total credits	3
Applicable majors	Computer science and technology
Prerequisite courses	Digital electronic technology, programming
Course category	Professional basic courses

The basic information of the course is shown in Table I. This course mainly discusses the basic composition of computers, the structure and working principles of various components. It belongs to the computer hardware technology series and is a compulsory course for computer majors. On the basis of digital electronic technology and programming courses, this course focuses on cultivating students' basic abilities such as understanding the internal structure of computers, working principles, and indicator measurement, learning complex computer system timing control methods, improving abstract thinking ability, guiding students to discover problems, analyze problem characteristics, and provide reasonable solutions, so as to cultivate students' ability to solve complex problems. This course pay attention to the integration of basic knowledge and new technologies, the transformation of theory into practice, and the cultivation of students' engineering awareness and ability.

II. COURSE OBJECTIVES DECOMPOSITION AND GRADUATION REQUIREMENTS

A. Page Layout Course objectives decomposition

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The objectives of this course is to help students understand the working principles of von Neumann structured computers through relevant teaching activities, master the structure, working principles, internal operating mechanisms, and design methods of hardware functional components and hardware systems of the basic components of computers (including processors, memory, controllers, buses, input/output systems). Meanwhile, by establishing a complete machine concept of hardware/software collaboration, students' computer system analysis and design abilities are enhanced. The specific objectives of the course include:

Course objective 1 (CO1): Master the basic composition structure and working principles of modern digital computers, as well as the structure and working principles of arithmetic units, memory, instruction systems, controllers, memory, buses, and input/output systems; Establish a system view of software and hardware collaboration, and be able to use specialized knowledge such as data representation, computational methods, and instruction systems to infer and analyze computer system design solutions and models.

Course objective 2 (CO2): Have a deep understanding of the composition, structure, and working principles of multi-level storage systems such as cache memory, virtual memory, and disk. Be able to use the above knowledge and relevant models to compare and select appropriate solutions to design computer functional components and computer system.

Course objective 3 (CO3): Master basic quantitative methods such as CPU performance evaluation, pipeline performance analysis, and input output systems. Master the design process and methods of hardware functional components such as ALU and controllers that meet specific functional requirements, as well as computer hardware systems. Be able to use the aforementioned quantitative methods to analyze key factors affecting computer hardware design, and have the ability to verify the rationality of solutions and optimize them.

B. Title and Author Details The support for graduation requirements and indicator points based on course objectives

The graduation requirements mainly include the cultivation of engineering knowledge and problem analysis ability. The corresponding relationship between the course objectives and the indicator points in the graduation requirements is shown in Table II.

TABLE II. Correspondence between course objectives and graduation requirements indicators

Course objectives	**Graduation requirements**	**Indicator points in graduation requirements**	**Principal teaching procedures**
CO1	Engineering knowledge	The ability to apply mathematics, natural sciences, engineering fundamentals, computer professional knowledge, and mathematical model methods to the analysis process of complex engineering problems in the computer field.	Strengthen the cultivation of structural and systematic perspectives. Among them, the construction perspective emphasizes the design and implementation of basic functional components and digital systems, which is the most basic teaching method for hardware courses; The system view emphasizes the impact of hardware structure on the correctness or performance of software operation, and is an effective method for cultivating system engineers.
CO2	Engineering knowledge	Be able to apply basic knowledge and expertise in mathematics, natural sciences, engineering to the comparison, optimization, synthesis, and improvement of solutions for complex engineering problems in the computer field.	Emphasize the cultivation of engineering concepts. The engineering perspective helps students consider engineering constraints, such as the speed, cost, and capacity of multi-level storage systems, and establish a sense of selecting appropriate technical solutions and optimizing engineering.
CO3	Problem analysis	The ability to use the basic principles of mathematics, natural sciences, and engineering sciences to identify and judge the key factors of complex engineering problems in the computer field.	Developing problem-solving skills. Focusing on the key and difficult points of course teaching, carefully design several exploratory questions related to CPU performance evaluation and pipeline performance analysis, guide students to think deeply, deepen their understanding of key factors affecting computer hardware design, and enhance students' ability to verify the rationality of solutions and optimize them.

The cultivation of engineering knowledge requires the ability to apply mathematics, natural sciences, engineering fundamentals, and professional knowledge to solve complex software engineering problems.

The corresponding indicator points for engineering knowledge cultivation are, on the one hand, the ability to apply mathematics, natural sciences, engineering fundamentals, computer professional knowledge, and mathematical model methods to the analysis process of complex engineering problems in the computer field. On the other hand, it is possible to apply basic knowledge and expertise in mathematics, natural sciences, engineering to the comparison, optimization, synthesis, and improvement of solutions for complex engineering problems in the computer field.

The cultivation of problem analysis ability requires the ability to apply the basic principles of mathematics, natural science and engineering science to identify, express, and analyze complex engineering problems in the computer field through literature research to obtain effective conclusions.

The corresponding indicator point for cultivating problem analysis ability is the ability to use the basic principles of mathematics, natural sciences, and engineering sciences to identify and judge the key factors of complex engineering problems in the computer field.

III. COURSE ASSESSMENT METHODS AND CALCULATION METHODS FOR ACHIEVING COURSE OBJECTIVES

A. Course assessment content and method

Table III lists the assessment content, score composition,

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and proportion corresponding to the three course objectives. The score is mainly composed of online task, online test and final examination, accounting for 20%, 20% and 60% respectively. In addition, the proportion of assessment scores for the three course objectives is 35.4%, 37.8%, and 26.8%, respectively.

TABLE III. Course Assessment Content and Score Composition

Course objective	Assessment content	Composition and proportion of scores (%)			Total (%)
		Online Task	Online test	Final test	
CO1	• Computer performance analysis and evaluation; • Multi function ALU verification analysis; • Data format and data representation methods, IEEE754 standard, calculations related to full adders and multipliers, overflow detection methods; • Analysis of instruction format and Instruction cycle;	5%	10%	20.4%	35.4%
CO2	• Multi level memory design; • Organizational structure and performance analysis of Cache; • Organizational structure and performance analysis of virtual memory; • Analysis of graphics memory performance and design of peripheral device structure;	5%	10%	22.8%	37.8%
CO3	• Pipeline performance analysis; • Principles and design methods of Microcode; Microinstruction format analysis and design; • Quantitative analysis method for input output system performance;	10%		16.8%	26.8%
Total		20%	20%	60%	100%

B. Calculation method for achieving course objectives

The calculation method for evaluating the degree of achievement of course sub objectives and overall objectives is shown in formulas (1) and (2):

$$\text{Achievement degree of } CO_i = \frac{\text{Average score of sub objective}}{\text{Total score of sub objective}} \quad (1)$$

$$\text{Achievement degree of CO} = \frac{\text{Average score of course objective}}{\text{Total score of course objective}} \quad (2)$$

TABLE IV. Calculation method for achievement degree

Course objective	Assessment method	Target score	Student average score	Example of achievement degree
CO1	Online task	A(=100×5%)	A1(= The average actual score of the student in this item×5%)	$\frac{A_1+B_1+C_1}{A+B+C}$
	Online test 1	B(=100×10%)	B1(= The average actual score of the student in this item×10%)	
	Final test	C(=34×60%)	C1(= The average actual score of the student in this item×60%)	
CO2	Online task	D(=100×5%)	D1(= The average actual score of the student in this item×5%)	$\frac{D_1+E_1+F_1}{D+E+F}$
	Online test 2	E(=100×10%)	E1(= The average actual score of the student in this item×10%)	
	Final test	F(=38×60%)	F1(= The average actual score of the student in this item×60%)	
CO3	Online task	G(=100×10%)	G1(= The average actual score of the student in this item×10%)	$\frac{G_1+H_1}{G+H}$
	Final test	H(=28×60%)	H1(= The average actual score of the student in this item×60%)	
Course Objective	Total score	100	A1+B1+C1+D1+E1+F1+G1+H1	$\frac{A_1+B_1+C_1+D_1+E_1+F_1+G_1+H_1}{A+B+C+D+E+F+G+H}$

The specific data description and calculation examples are shown in Table IV. The letters A, B, and C represent the target scores of online task, online test, and final test corresponding to CO1 in the total score; The letters D, E and F represent the target scores of online task, online test and final examination corresponding to CO2 in the total score; The letters G and H respectively represent target scores of the online task and final examination corresponding CO3 in the total score.

The letters A1, B1 and C1 represent the actual average scores of students in the online task, online test and final examination corresponding to the CO1 in the total score; The letters D1, E1 and F1 represent the actual average scores of the students in the online task, online test and final examination corresponding to the CO2 in the total score; The letters G1 and H1 represent the actual average scores of students in the online task and final examination corresponding to the CO3 in the total score.

IV. ANALYSIS OF THE DEGREE OF ACHIEVEMENT FOR COURSE OBJECTIVES

Table V shows the distribution and scores of the computer composition principle test in the second semester of 2022-2023 for the undergraduate majoring in computer science and technology of Anhui University of Finance and Economics.

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TABLE V. Quantitative results of course objective achievement

Course objective	Assessment method	Question type	Target score	Assessment ratio	Total score	Average score	Achievement degree
CO1	Online task	Online task 1	100	5%	100	87	0.7727
	Online test	Online test 1	100	10%	100	85	
	Final test	Single choice (1-3,6)	8	60%	34	25.01	
		Fill in the blanks (1-2,8)	3				
		True or false (1-2,6)	3				
		Comprehensive application (1,3)	20				
CO2	Online task	Online task 2	100	5%	100	89	0.7298
	Online test	Online test 2	100	10%	100	82	
	Final test	Single choice (4-5,8-9)	8	60%	38	26.03	
		Fill in the blanks (3-6,9)	5				
		True or false (3-5,8-9)	5				
		Comprehensive application (2,5)	20				
CO3	Online task	Online task 3	100	10%	100	88	0.7313
	Final test	Single choice (7,10)	4	60%	28	18.99	
		Fill in the blanks (8,10)	2				
		True or false (7,10)	2				
		Comprehensive application (4,6)	20				

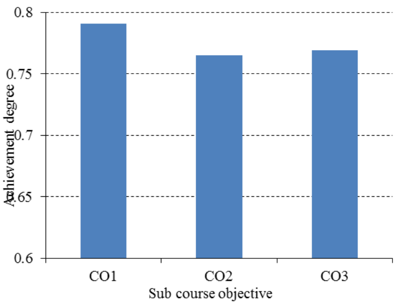

Fig. 1. Achievement degree of sub course objective

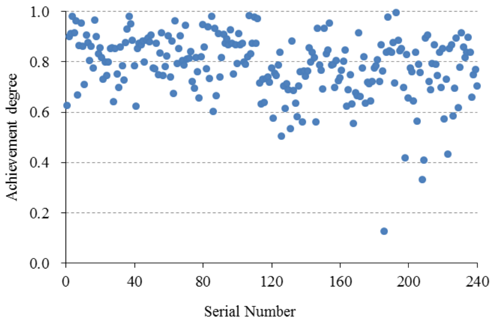

Fig. 2. Distribution of achievement degree for CO1

Fig.1 shows the achievement degree of sub course objective. It can be seen that the achievement values of each sub course objective are within the range of [0.70,0.80], indicating a good degree of achievement. In addition, the distribution of achievement values for each sub course objective is relatively average, and the overall achievement is good.

Fig. 2, Fig. 3 and Fig. 4 respectively describe the distribution of achievement degree for CO1, CO2 and CO3 of 240 undergraduate students in 2020 (including 3 students in 2018 and 3 students in 2019).

Overall, most students' achievement values for each sub course objective exceed 0.60, a few students' achievement values are below 0.50, and very few students' achievement values are below 0.40, indicating that the overall achievement level of the course is good.

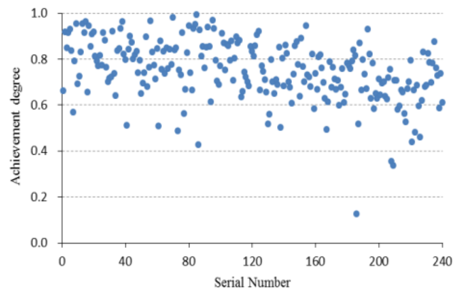

Fig. 3. Distribution of achievement degree for CO2

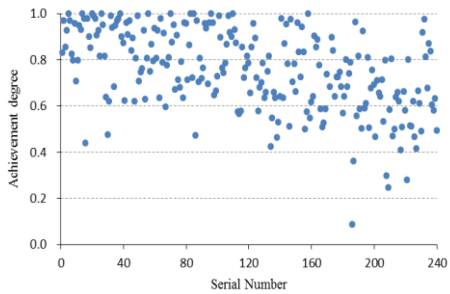

Fig. 4. Distribution of achievement degree for CO3

From the perspective of the achievement degree of each sub course objective, students' scores in CO1 and CO2 are relatively average, indicating that students have a good understanding of data representation, instruction format analysis, and multi-level storage system. However, the distribution of points in Fig. 4 is relatively scattered, indicating that many students' abilities in central processing units, pipeline performance analysis, and I/O system analysis need to be further strengthened.

Finally, there are some students who have not achieved ideal course objectives, mainly those who have retaken the course. The main reason for this is their lack of discipline and failure to complete online assignments and tests on time. This indicates that it is necessary for colleges and course teachers to take effective measures to help these students, especially to correct their learning attitude and achieve course objectives before graduation.

V. Conclusion

Generally, from the analysis of course objectives and individual achievement, it can be concluded that the teaching content, teaching methods, and assessment methods can meet all the needs of course objectives. It is worth noting that for teachers, pipeline performance analysis methods and I/O system analysis methods should be strengthened to help students build engineering concepts. For university management departments, it is necessary to strengthen student management and ideological education, so that students fully understand the importance of courses and complete various course tasks on time with quality.

Acknowledgment

This research was supported in part by the National Natural Science Foundation of China under grant No. 61704001, Anhui Provincial Natural Science Foundation under grant No. 1808085QF196, in part by the Natural Science Foundation of the Higher Education Institutions of Anhui Province under grant No. KJ2021A0484.

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