Blending Teaching Mode for Computer Courses in the Background of Emerging Engineering Education

A Case Study of Principle and Application of Database

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Abstract—This study highlights the creation of a curriculum system and teaching mode that adapts to the information era. According to an analysis of the shortages of traditional teaching mode for the course *Principle and Application of Database* and the status of teaching, a blending teaching mode design in the background of emerging engineering education, a case-driven reversal experimental teaching technique, and an assessment mechanism formulated in accordance with an analytic hierarchy process (AHP) are proposed. Relevant teaching activities are designed in detail. The new teaching mode considers the learning initiatives of students and individual acceptance differences. Assessment results and feedback from the data analysis of online investigation indicate that the improved teaching mode enhances teaching quality effectively. Moreover, the annual average growth of performance proportion that is better than "good" is 13% in the recent three years. Finally, the acceptability and satisfaction rates of students are higher than 90%.

Keywords—Blending teaching, case, AHP, learning initiative

1 Introduction

As a compulsory course for computer majors in college, the course Principle and Application of Database covers theories, abstract concepts, high operation requirements, and rapid technological updates [1]. This course requires students to make a detailed database analysis and design for specific application systems while gaining mastery of an application development tool and to develop a complete database application system. This course, therefore, trains students on computational thinking, database analysis, and system design ability. It proposes many requirements on the comprehensive applicability and ability of students. According to previous teaching practices, this course has some characteristics. First, it targets the mastery of systematic disciplinary knowledge and has an evident discipline orientation. Second, it teaches database-related theories and SQL programming from chapter to chapter by focusing on relational database management system. Moreover, it is taught in a large class with after-class exercises, centralized Q&A, and final examination. Third, the course includes many verification and simulation experimental studies but has limited creation and design content. It has poor connection and expansion of experimental cases, which bring students great challenges in connecting the learned knowledge with the overall development of database management system project and in solving practical engineering application problems with experimental knowledge. Fourth, the course uses a single assessment mode, which hardly reflects students' individual abilities in independent learning and comprehensive design.

The phenomena can be explained from the following aspects. First, the pursuit of discipline-oriented curriculum value leads to knowledge objective overweighing skill objective. Second, the teaching mode, which is centered on teachers' teaching, ignores the dominant role of students as knowledge constructors; in other words, this mode regards students as just passive acceptors of knowledge. Hence, the training of students' innovative thinking is affected. Third, the experimental case design based on a verification mode leads to the differences in students' practical ability and enterprises' requirements on talent application ability. These reasons influence training quality of college students who major in computers and relevant subjects to some extent and cause a series of bad chain reactions that can induce a series of problems, including the poor adaptation of students to jobs after graduation and the decreasing social acceptance of universities.

In light of the above, exploring a curriculum system that pays equal attention to the knowledge, skills, and innovation training of students and adapting to the requirements of the current information era are the key problems to be solved in this curriculum reform. Meanwhile, blending teaching mode is a new normal state [2-3] in future education. On the basis of the organic combination of classroom teaching and online learning, the blending teaching mode realizes the reconstruction of teaching mode and the supplementation of the advantages of different teaching modes by the deep combination of different learning environments, learning methods, and evaluation modes. It can fully develop the guidance and teaching supervision role of teachers and attract students from the traditional passive learning environment into an independent learning atmosphere, thus improving students' learning abilities. The construction of emerging engineering education proposes an industrial demands-oriented curriculum objective, innovative engineering education modes and means, student-centered teaching philosophy, and engineering education efficiency and teaching effect [4]. In this background, the study discusses the improvement of teaching mode for the Principle and Application of Database course using the deep blending teaching mode.

2 State of the Art

Principle and Application of Database integrates theory and practices. To train students' operational and technological innovation ability, many scholars have deeply explored the blending teaching mode and improved their teaching modes by combining traditional classroom teaching with the case study teaching mode, problem-based learning (PBL) method, and the MOOC platform.

With respect to the teaching mode design for Principle and Application of Database, in the background of a professional certificate for engineering education, Reference [5] introduced in the MOOC blending teaching and reformed the teaching mode for the curriculum according to the outcome-based education theory. Another study [6] divided the database curriculum into classroom learning, experiment practice, and online studying and applied the teaching mode based on hybrid learning theory, achieving good effects. References [7] adopted the project-based learning, which realized the goal of training applied talents, adapting to the demands of enterprises to some extent. Meanwhile, past works [8] studied the blending teaching strategy of PBL, which could facilitate students to participate in and finish learning activities effectively. Reference [9] applied the ability-oriented teaching mode and focused on the training and improvement of students' ability to adapt to the training of applied talents. Another study [10] pointed out that anonymous online discussion and cooperation can serve as an effective blending teaching strategy, which can reduce the pressure and fear and increase the participation initiatives of students.

These reforms reflect breakthroughs that learners achieve in curriculum objective orientation, teaching content and method, and the transfer of learning rights through the blending teaching mode. However, with respect to curriculum objective orientation, these reforms still focus on disciplines or abilities, which are inapplicable to computer courses. These courses shall pay close attention to the latest industrial demands due to the high update frequency. Although the case study teaching mode realizes the goal of training applied talents to meet enterprises' demands, none of the above studies has mentioned the challenges, sources, and fitness of projects with enterprises' demands. Furthermore, these reforms also neglect the individual education of different students even though they considered independent learning ability and engagement.

With respect to learning assessment, one study [11] used a members' mutual assessment strategy and pointed out that this strategy could stimulate and maintain strong learning interests and enhance effective learning outcome of students. Other works [12-13] reported that systematic and long-term evaluation data acquisition is the basis for effective assessment. Some scholars have attempted to assess blending teaching by using different conceptual frameworks from different perspectives, such as classroom community awareness [14-15], student participation and interaction [16], PBL framework [17], and activity theory [18]. However, researchers have not yet created an effective assessment mechanism for blending teaching in teaching practices and still do not know which frameworks and tools must be used to assess blending teaching.

The study proposes the creation of requirements for emerging engineering education and industrial demands-oriented curriculum objective. The blending teaching mode, which is improved from the curriculum teaching method, assessment method, assessment feedback, and transfer of learning rights, is applied in theory. The case study teaching mode is used to conduct an experiment on a part in which practical database development projects and working flowchart of enterprises are brought into the experimental process. Driven by tasks, students train to gain theory-practice integrated skills through a reversal classroom, which can help solve the mismatch between practice teaching in universities and enterprises' demands. The whole teaching implementation is finished by blending teaching mode and case study teaching mode.

3 Curriculum System Framework and Blending Teaching Mode

Simply put, blending learning is a learning mode that can achieve the optimal learning effect by applying the "right" learning technologies to match the "right" personal learning style to transfer the "right" skills to the "right" person at the "right" time [19]. According to this definition and with reference to the theoretical design framework of Huang Ronghuai [20], the design of the blending teaching mode can be divided into the following components: early analysis, teaching design, learning evaluation design, and teaching verification, as shown in Fig. 1.

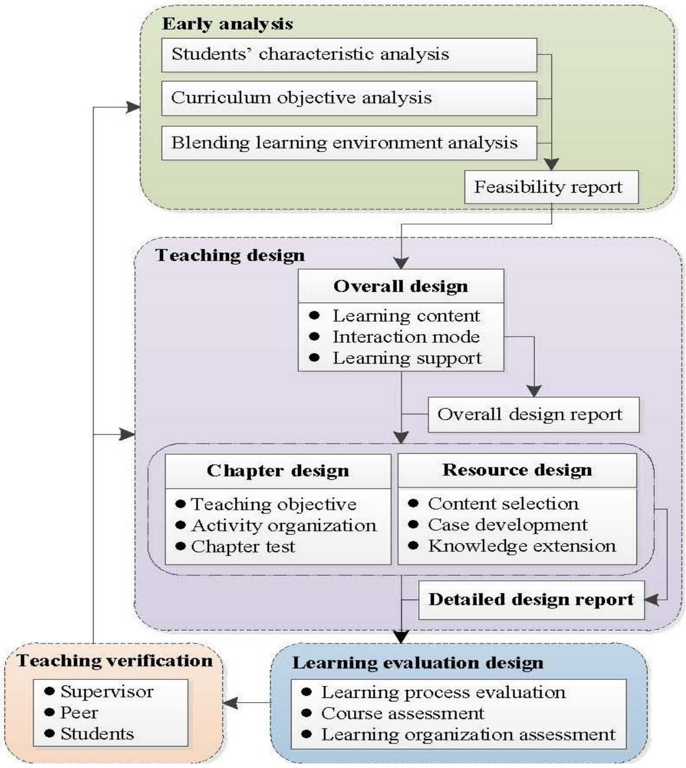


Fig. 1. Blending teaching design framework

The first stage is early analysis. This stage gains the feasibility report of blending teaching mode and determines the teaching objective by analyzing students' characteristics, the curriculum objective, and the blending learning environment. This stage thus lays the foundation for follow-up stages.

The second stage is teaching design, which is composed of the overall design of blending learning, chapter design, and resource design. On the basis of an understanding of the overall objective of the curriculum, designers decide which contents and resources are appropriate for online learning and which are appropriate for a typical classroom environment. Next, they arrange the learning activities in order and determine the corresponding teaching mode. They also write an overall design report to express the main ideas and expectations of the curriculum design, which provides references for chapter and resource designs.

The third stage is learning evaluation design, which is mainly to evaluate the learning effect through the learning process and academic performance assessment.

The final stage is teaching verification wherein teaching shortcomings are corrected according to curriculum opinions proposed by supervisors, peers, and students. These opinions are iterated to the next teaching period for further improvement.

Based on the principle of the blending teaching design framework, the objective system for Principle and Application of Database is revised, and the teaching content, teaching mode design, and assessment method are reorganized in the following text.

3.1 Curriculum objective determination and content selection

Computer courses are characteristic of fast-changing market demands for talents and high knowledge updating frequency. Therefore, an industrial demands-oriented curriculum objective is determined based on the national emerging engineering education and the university's orientation to the training of applied talents.

The following text analyzes current industrial demands. The curriculum team sorted out professional post groups related with computers and the typical work tasks through an investigation; the team extracted common requirements for database engineer positions and jobs of Huawei Technologies Co., Ltd. [21]; Sinosoft Co., Ltd. [22]; and Weaver [23] in January 2020. On the one hand, enterprises demand talents who are equipped with fundamental, professional, and extension database knowledge; familiar with database development software; and skilled at related technologies. On the other hand, applicants of these posts should have good communication, expression, self-learning, innovation, and team-working abilities.

On the basis of the above analysis on industrial demands, the curriculum objective is divided into knowledge level, skills training, and innovative thinking. According to the cognitive level, knowledge level is further divided into fundamental, deep, and extension knowledge. Skills training refers to skills, social relations, and other abilities that are needed to finish comprehensive projects with equivalent challenges to enterprises' demands. This can be further divided into analysis and use of technologies, independent learning, organization management, team-working, communication, and competition. Innovative thinking means perception and logical thinking abilities, which are needed in database design based on the innovation idea, and is measured by perception level, logic thinking, and innovation. Curriculum objective assessment has 3 dimensions and 13 observation points.

The curriculum team adjusts contents and selects 20 knowledge units for Principle and Application of Database according to the cognitive process, which is composed of proposing problems, analyzing problems, solving problems, and new exploration. Two-dimensional (2D) supporting matrixes of objective dimension and knowledge units are listed according to teaching objectives of these 20 knowledge units. Table 1 shows the corresponding relations.

Table 1. Two-dimensional supporting matrix of objective dimension and knowledge units

Knowledge units \ Objective dimension			Knowledge level (assessment)			Skills training (measurable)							Innovative thinking (trying to improve)		
			Fundamental	*Deep*	*Extension*	*Analysis*	*Use*	*Independent learning*	*Organization management*	*Team-working*	*Communication*	*Competition*	*Perception*	*Logic thinking*	*innovation*
Introducing problem		Data management demands	■		■			■			■				
		Basic concept	■												
Analyzing problem	Database theory	Data model	■										■		
		Mode/mapping		■				■					■		
		Relation database	■			■		■					■		
		Normalization		■		■		■					■	■	
		Mode decomposition		■	■	■		■						■	
Solving problem	Database operation	SQL data operation	■	■	■	■	■	■	■	■	■	■	■		
		View	■	■		■	■	■	■	■	■	■	■	■	
		Safety	■			■	■	■			■	■	■		
		Integrity		■	■	■	■	■			■	■	■		
		Assert			■	■	■	■			■	■	■		
		Trigger		■		■	■	■	■	■	■	■	■	■	
		Storage process		■		■	■	■	■	■	■	■	■	■	
		Embedded SQL			■	■	■	■			■	■	■		
	Operation maintenance	Recover technology			■	■		■			■		■		■
		Concurrency control			■	■		■			■		■		■
New exploration		Big data management			■	■		■					■		
		Data mining			■	■		■					■		
Experiment	Database design				■	■	■	■	■	■	■	■	■	■	■

3.2 Blending teaching mode design

The teaching mode centered on traditional instructional approaches can help improve students' primary receptive learning, but it faces difficulty in meeting the teaching objective of industrial demands-oriented curriculum. To realize the overall curriculum objective from the perspective of knowledge acceptance, the blending teaching mode advocates student-centered mode, expanding learning, and selective learning to awaken students' consciousness of the subject in all the learning activities. Given the curriculum content organization, knowledge teaching, database programming, and project design are designed as the macroscopic structure of the whole teaching process. These three teaching activities contain 20 knowledge units in Table 1. The corresponding relations are shown in Fig. 2.

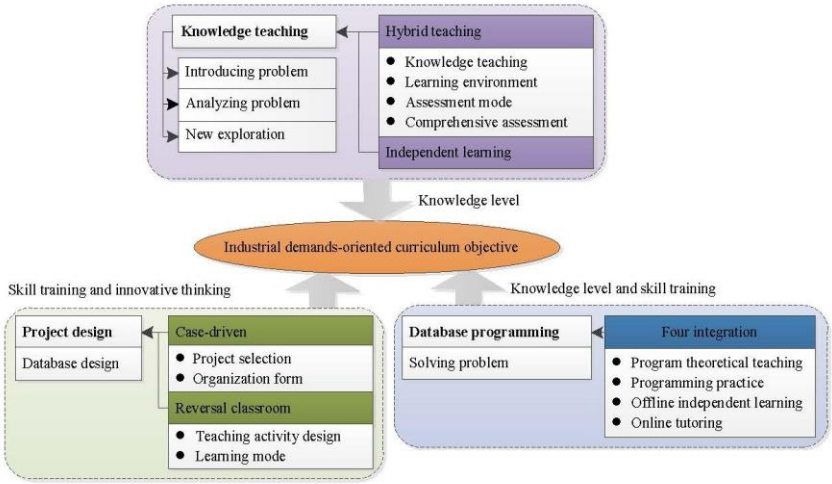


Fig. 2. Teaching activities and curriculum objective s

A framework is designed in which three teaching activities supplement each other and support the overall curriculum objective together (Fig. 2). In the teaching process, three teaching activities are performed according to the knowledge sequence and independently so in accordance with specific teaching plans. The implementation methods of all three teaching activities are introduced as follows.

Knowledge teaching covers the knowledge units of introducing the problem, analyzing the problem, and new exploration in Table 1. It supports the overall curriculum objective through the dimension of knowledge level and follows the following teaching strategy: with consideration for interactive learning environments, classroom teaching and online teaching are combined comprehensively, after which the curriculum objective is realized through diversified integrations of knowledge teaching, learning environment, assessment mode, and comprehensive assessment. In the teaching process, teacher instruction, platform learning, real-time discussion, forum communication, individual tutoring, investigation sharing, and other teaching approaches are utilized to activate the atmosphere in traditional classroom teaching.

Database programming refers to the knowledge unit of solving problem and is the key activity to improve students' ability to analyze and solve problems. It emphasizes the objective of skill training and significantly influences the realization of the dimension of knowledge level. Database programming follows the teaching strategy to determine the students' role in learning activities, attract students to the independent learning atmosphere, and accord the teachers the role of organizers and managers of teaching activities. Moreover, the teaching mode that integrates program theoretical teaching, programming practice on computers, offline independent learning, and online tutoring is applied.

Project design applies the case-driven and reversal classroom teaching mode and it integrates the fundamental knowledge. With respect to project selection, experimental cases and practical enterprise projects are combined to train the analysis application, perception, and innovation abilities of students, thus ensuring that the ability output of students meets the enterprises' demands. Given the organization form, students are grouped in a similar way as the database project teams in enterprises, and the role of each group member is determined. Each group member must finish the role independently and cooperate with the team to accomplish the overall task. With respect to teaching activity design, students shall compete and cooperate to train their competitiveness and cooperation consciousness. This training can stimulate the self-efficacy of students. As for the learning mode, project design advocates combining independent and cooperative learning, which emphasizes the individual learning process and the advantages of group learning in training organization and management abilities, team-working abilities, and communication and understanding abilities of students.

3.3 Formulating a performance assessment system based on AHP decision-making

This study increases the process assessment proportion when formulating a performance assessment system and sets up a ranking of different evaluation indexes according to the AHP.

The AHP is a theory of relative measurement on absolute scales of both tangible and intangible criteria based both on the judgment of knowledgeable and expert people and on existing measurements and statistics that are required to make a decision [24]. The procedure of applying AHP is based on three principles, namely: construction of a hierarchy, priority setting, and logical consistency [25].

The steps of AHP are introduced as follows.

Constructing a hierarchical index system: It has at least three layers: the overall goal of the problem at the top, multiple criteria that define alternatives in the middle, and decision alternatives at the bottom [26]. The hierarchical structure that is used to prepare the learning effect assessment system (LEAS) in this study is shown in Fig. 3. The top layer is the objective layer, the overall performance assessment (A). The second layer is the criteria layer, which involves four indexes: traditional teaching (B1), online learning (B2), experimental practice (B3), and program development (B4). The third layer is the decision layer, which involves 15 indexes (C1–C15).

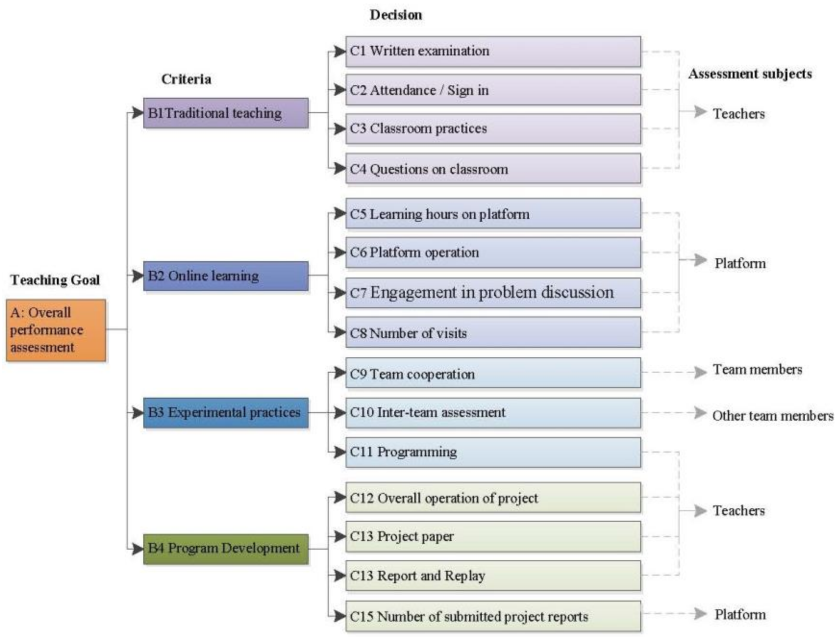


Fig. 3. Hierarchical structure of the LEAS

Priority setting and weight calculation. A (n× n) evaluation matrix U is constructed.

$$U = \begin{bmatrix} u_{11} & u_{12} & \dots & u_{1n} \\ u_{21} & u_{22} & \dots & u_{2n} \\ \dots & \dots & \dots & \dots \\ u_{n1} & u_{n2} & \dots & u_{nn} \end{bmatrix}, u_{ii} = 1, u_{ji} = \frac{1}{u_{ij}}, u_{ij} \neq 0 \tag{1}$$

The relative "priority or weight" given to each element in the hierarchy is determined by comparing pairwise the contribution of each element at a lower level in terms of the criteria (or elements) with a causal relationship. The pairwise judgment starts from the second level and finishes at the lowest level. In each level, the criteria are compared pairwise according to their level of influence and based on the specified criteria in the higher level. The decision-maker then uses a standardized comparison scale, which involves nine scales (Table 2).

Table 2. Nine-level intensity of importance scale and its description

Scales	Instructions
1	Both elements are equally important.
3	One element is moderately more important than the other one.
5	One element is strongly more important than the other one.
7	One element is very strongly more important than the other one.
9	One element is extremely more important than the other one.
2, 4, 6,8	Intermediate values
$1/u_{ij}$	Reverse comparison of two elements

The weight of a single layer is calculated. The weight and maximum eigenvalue of a single layer are calculated approximately according to the square root method. The steps of square root method are introduced as follows.

Step 1: Calculate the product of each row of elements in the judgment matrix U .

$$M_i = \prod_{j=1}^{n} u_{ij}, i = 1, 2, ..., n \tag{2}$$

Step 2: Calculate the n^{th} root of M_i.

$$\overline{W}_i = \sqrt[n]{M_i} \tag{3}$$

Step 3: Normalize $\overline{W}_i$ to W_i. W_i is the desired eigenvector.

$$W_i = \frac{\overline{W}_i}{\sum_{j=1}^{n} \overline{W}_j} \tag{4}$$

Step 4: Calculate the maximum eigenvalue $\lambda_{\max}$, where $(UW)_i$ is the i^{th} component of vector UW .

$$\lambda_{\max} \approx \sum_{i=1}^{n} \frac{(UW)_i}{nW_i} \tag{5}$$

Single ranking and logical consistency test of indexes in each layer. Calculate consistency index (CI).

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{6}$$

Calculate CI/random index (RI) (Table 4), which is known as the consistency ratio (CR).

$$CR = CI/RI \tag{7}$$

The upper limit value of CR is 0.1. If the final CR exceeds it, the evaluation procedure has to be repeated to improve consistency.

Table 3. Random Index

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14
RI	0	0	0.52	0.89	1.12	1.24	1.36	1.41	1.46	1.49	1.52	1.54	1.56	1.58

In practical applications, the system formulates assessment weights in accordance with the experts' suggestions and supervision feedback and then carries out the decision-making analysis. Section 4 introduces the operation steps.

4 Case Study and Teaching effect

4.1 Case study

The proposed blending teaching mode has been practiced for three cycles. In this program, college students majored in computer were chosen as respondents, and double-qualified teachers were invited to form a faculty team of the project. The database curriculum team accomplished knowledge teaching, database programming, and project design according to curriculum objective, including publishing teaching objective, arranging teaching plan, designing blending teaching mode, selecting cases, drafting grouping schemes, task design, and revising assessment system.

Early preparation for teaching activities: First, the MOOC platform was selected for online learning. The class was initialized, and the learning documents were uploaded. The MOOC platform used the MOOC of Chinese university (www.icourse163.com), and the reference learning platform was Super-star MOOC (http://fanya.chaoxing.com/). The teachers initialized the class and published curriculum objectives, teaching plans, and learning guidelines on the chosen platform. The students, all in their senior year, were asked to register with their real student numbers and names and join in the class to finish online learning tasks.

Second, credit hours for learning on the MOOC platform were determined. According to teaching objective, the traditional classroom teaching content and online learning content were determined and allocated. A principle was followed during allocation. Chapters emphasizing on theoretical difficulties and key algorithms were allocated to traditional classroom teaching, whereas chapters with many textual narrations and easy to be learned independently were allocated to the MOOC platform. In this case study, the students who were admitted to information and computing science were chosen as respondents. The curriculum had 56 credit hours, including 24 credit hours for traditional classroom teaching; 24 credit hours for knowledge summary, questioning, and group discussions of students; and 8 credit hours for database project design. The online fragmented MOOC platform comprised at least 20 credit hours (excluding credit hours in the teaching plan). Classroom teaching content and online teaching content were matched. All knowledge points are coherent and accompanied by the expansibility of knowledge quantity and the selection of knowledge extension in accordance with individual differences.

Third, an experimental environment was built. (1) The experimental computer room was equipped with Windows 7+, SQL SERVER 2008+, Microsoft Visual Studio 2015+, Microsoft VISO 2010+, and other basic software, which were used as the database development environment. (2) The students were asked to install the above operating environment on their laptops. They were then grouped by the principle that each group had at least one laptop with the above operating environment for after-class practices. (3) Those with strong manipulative ability were allowed to extend the practice of Linux, Oracle, and other database environments to meet the higher requirements of enterprise posts to graduates.

Fourth, the database project case was determined. The experimental program is expected to meet the demands of enterprises. The curriculum team appropriately revised the practical enterprise database development project, Design for Students' Performance Management System, according to the database experimental syllabus for undergraduate students. This project helped students to understand the real database project designs of enterprises. Considering the differences of students in program development capabilities, students with strong manipulative ability could choose the second candidate enterprise project, Design for Name Card Management System (database projects come from enterprises, and students mainly finished projects through guidance teaching and independent learning).

Pre-class preparation: The teachers published enough systematic and comprehensive teaching tasks and learning resources of a chapter on the MOOC platform, including curriculum objective, PPT courseware, teaching video, experiment instruction, project case, and references. The students received these teaching materials and made independent learning with questions. After summarizing the learned content, the students proposed several questions that they had encountered during independent learning on the forum of MOOC platform and initiated or participated in discussions. In turn, the teachers answered the questions of the students, summarized common problems, and adjusted classroom teaching according to preview feedback.

Deep interaction, exploration, and communication on classes: For knowledge teaching, database programming, and project design, the dominant-subject teaching mode is implemented throughout the classroom. The blending teaching mode was used fully in knowledge teaching. First, the teachers asked questions about knowledge points of the lesson according to preview feedback on the MOOC platform to test the independent learning of students. Second, the teachers summarized knowledge points, taught key content, especially the content that students were weak at, and answered questions that were not solved during the preview to help the students further organize knowledge points and strengthen correct understanding. Third, the reversal classroom was introduced appropriately, and some students who acquired the knowledge well were invited to explain what they had learned. The teachers could correct and supplement the misunderstood and inadequate knowledge of students. Finally, the teachers guided students in group discussions on taught content according to the principle of seat proximity, and each group assigned a member for the discussion report and answered doubts of other groups. Through group discussions and communications, students could make a judgment, determine advantages and disadvantages, deepen knowledge and understanding, and improve logical analysis and practice ability.

Database programming and project design further highlight group discussion and student-centered philosophy. The reversal classroom teaching mode is highly appreciated in these two teaching activities. The students' differences in problem analysis, solving, and manipulative ability are reflected in these two teaching activities. To learn from others' strong points to offset their weaknesses and train team cooperation ability, students were divided into groups that are similar to database project teams in an enterprise to undertake tasks. Each group had five to six members, and everyone assumed a certain role, thought independently, and cooperated to finish the feasibility analysis, E-R diagram design, flowchart design, and SQL programming. In this process, the teachers would further supervise over organization and management, organize students to have project discussions, answer students' questions, and provide ideas and suggestions. After class, the group members were asked to conduct program debugging and keep close cooperation. The leader of the group would organize conferences regularly and submit progress reports through the online platform to assure the smooth implementation of database program development.

After-class knowledge consolidation and appropriate extension: After class, students expanded learning through the platform. First, they all had to finish the unit test on the MOOC platform to check their comprehension of basic knowledge. Second, to promote advanced cognitive development of students, the teachers published explorative and open questions on the forum, organized students to make group discussions, and inspired them to make deep reflections. These activities focused on the training of students in problem analysis and solving. Finally, the teachers should fully consider the differences of students in knowledge adsorption and learning initiatives; offer sufficient extension resources for the students at different levels; and encourage students to make problem explorations, comprehensive analysis, and scheme design in the field of database applications. These actions could help students to develop comprehensive abilities in solving complicated engineering problems through diversified and multi-layer training.

Learning effect assessment based on AHP decision-making: First, the index system design norms in hierarchical structure were set up according to AHP through suggestions of evaluation experts and supervision feedback. On this basis, the evaluation indexes were designed (Fig. 3).

Second, with reference to the instruction of scales 1–9 in Table 2, each index was scored, and a judgment matrix was constructed. The weight vector was calculated, and logical consistency was tested. In the LEAS, five judgment matrixes of a criteria layer (B1–B4) and a decision layer (C1–C15) to the overall objective (A) were constructed, which were denoted as A (B1–B4), B1 (C1–C4), B2 (C5–C8), B3 (C9–C11), and B4 (C12–C15). The weight of every index was calculated by the root method. The CR values of these five judgment matrixes are 0.018, 0.015, 0.017, 0.053, and 0.015. All of them were lower than 0.1, indicating that they passed through consistency verification.

Then, the final weights were calculated, and the ranking of layers was determined. After the weights of different indexes were determined, the comprehensive weights and ranking of indexes were computed. The final ranking of layers is shown in Table 4.

Table 4. Comprehensive weights and ranking of elements

Criterion	Weight of criterion	Decision	Weight of decision	Comprehensive weight	Ranking
B1 Traditional teaching	0.491	C1 Written examination	0.629	0.309	1
		C2 Attendance/sign in	0.154	0.076	4
		C3 Classroom practices	0.122	0.060	6
		C4 Questions on classroom	0.095	0.047	8
B2 Online learning	0.306	C5 Learning hours on platform	0.484	0.148	2
		C6 Platform operation	0.166	0.051	7
		C7 Participation in problem discussion	0.219	0.067	5
		C8 Number of visits	0.130	0.040	9
B3 Experimental practice	0.125	C9 Team cooperation	0.218	0.027	11
		C10 Inter-team assessment	0.091	0.011	13
		C11 Programming	0.690	0.086	3
B4 Program development	0.078	C12 Overall operation of project	0.449	0.035	10
		C13 Project paper	0.287	0.022	12
		C14 Report and reply	0.139	0.011	14
		C15 Number of submitted project reports	0.126	0.010	15

The element layer of the LEAS covered all assessable learning behaviors of students in this curriculum. The ranking of indexes shows that the curriculum evaluation of the AHP scoring approach emphasizes written examination, learning hours on platform, programming, attendance/sign in, and participation in problem discussion. It also focuses on breaking the traditional theoretical knowledge assessment and paid more attention to process assessment. Therefore, the academic performance assessment can be considered highly scientific and reasonable. Moreover, the evaluation subjects were participants of the curriculum, including teachers, platforms, intra-team members, and inter-team members who could obtain objective assessments on students' knowledge and ability training in different links.

PDCA cycle feedback and continuous teaching improvement: A Deming cycle for continuous teaching improvement (Fig. 4) was formulated according to the PDCA cycle proposed by Shewhart, an American quality management expert. In Fig. 4, P refers to the planning stage, which includes curriculum objective and content selection; D refers to the execution stage, which includes pre-class, on-class, and after-class teaching processes; C is the assessment stage and is divided into process assessment and result assessment; and A is the feedback processing stage, and the curriculum objective is revised by teaching evaluation. The current stage is A; students, peers, and supervisors evaluated the curriculum objective, teaching content, teaching mode, and faculty conditions. By analyzing the feedback results, the curriculum team concluded that teaching shortages can be iterated into the next cycle for correction and that teaching quality can be improved continuously.

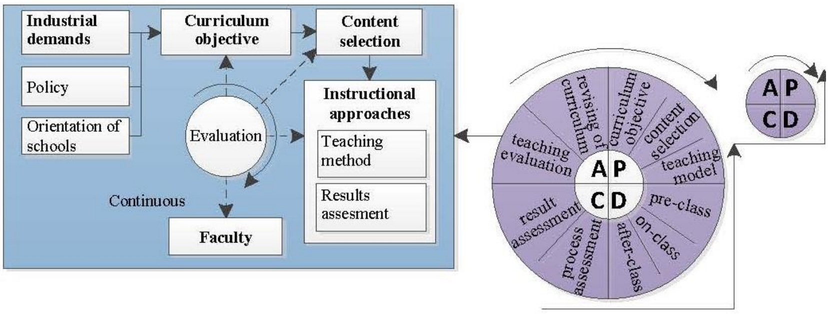


Fig. 4. Deming cycle of continuously improved teaching

4.2 Teaching effect

The implementation effect of the blending teaching mode is mainly evaluated by the learning effect of students and the teaching effect of teachers.

First, data analyses on the academic performance of 31 students admitted in 2014 (taught in 2017), 33 students admitted in 2015 (taught in 2018), and 32 students admitted in 2016 (taught in 2019) were carried out according to the LEAS. All students were from the same major. According to the score distribution of process assessment in Fig. 5, the proportion of objective assessment scores were decreasing gradually in the past three years, whereas the proportion of assessment scores on learning hours on the platform, engagement in problem discussion, team cooperation, and programming increased gradually. These proportions reflected that the teaching emphasis shifted to the ability and innovation training of students. Moreover, assessment thresholds were set to online learning, experimental practice, and program development (approximately 50% of the total scores). The students who had one of these three process assessments lower than the threshold were not allowed to take their final exams. Result assessment was performed through closed-book exams. According to score distribution, it conformed to the normal distribution in all three years (Fig. 6), which proved the reasonability of the assessment. The proportion of students who were assessed excellent and good increased year by year, whereas the proportion of students on the pass level and failure level decreased. Therefore, blending teaching assured high-level teaching quality, stimulated learning enthusiasm, and effectively improved the learning effect of students who had weak foundations.

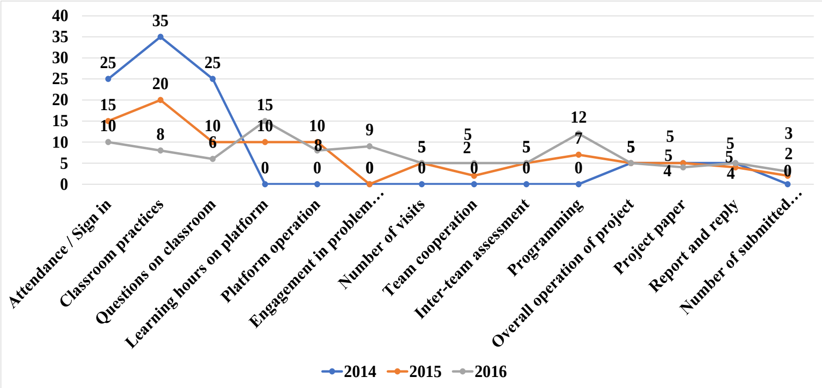
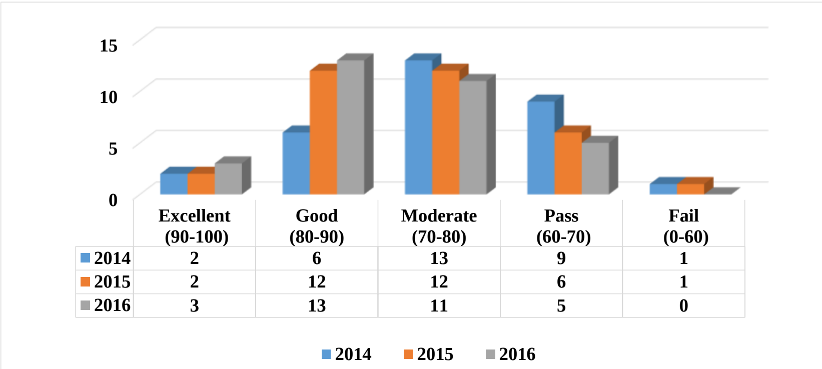


Fig. 5. Distribution of the process assessment scores of the students



	Excellent (90-100)	Good (80-90)	Moderate (70-80)	Pass (60-70)	Fail (0-60)
2014	2	6	13	9	1
2015	2	12	12	6	1
2016	3	13	11	5	0

Fig. 6. Final examination scores of the students

Second, curriculum acceptability was evaluated through an online questionnaire survey, which was conducted according to the principle of continuous teaching improvement based on PDCA. In the statistical analysis of the investigation results, 91% of the students approved the improvement teaching mode and believed that using a learning platform could expand their knowledge capacity and increase their interest in knowledge exploration significantly; 88% pointed out that combining traditional classroom teaching and online learning is necessary; 78% declared that the improved curriculum is conducive to training their manipulative ability, cooperation, and communicability; and 75% of the students pointed out that the curriculum stimulates their learning initiative and trains their creative thinking.

5 Conclusion

This study achieved the industrial demands-oriented curriculum objective in the background of emerging engineering education. The teaching contents and objectives were determined according to the 2D supporting matrix of 13 observation points in three dimensions and 20 knowledge units in three teaching activities. This curriculum was taught by combining the blending teaching mode and the case study teaching mode. The teaching effect of the curriculum was tested by the LEAS, which was formulated through AHP. Results showed that knowledge level and skills of students in the third year were higher than those of students in the previous two years. Finally, the teaching mode was improved continuously through the Deming cycle. According to three-year teaching practices, the following conclusions were drawn:

1. The deep blending teaching mode in the curriculum teaching model, learning environment, learning methods, and assessments can fulfill the teaching objectives and requirements. It also improves training on the knowledge foundation, skills, and innovative thinking of students.
2. The proposed teaching mode is an education technique that "weakens" the dominant role of teachers on class, returns learning rights to students, and considers individual differences of students. It can train the questioning spirit and critical consciousness of students, thus laying a solid foundation for ability training and innovative training. The proposed teaching mode realizes the goal of training students' interest in independent learning and knowledge exploration.
3. The training objective oriented to industrial demands-oriented improves the adaptation ability of students to have a career after graduation and increases the satisfaction of enterprises.
4. This teaching mode applies to all computer curricula, which combine theories and practices. It can also provide some references for other applied courses.

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