Research on Ability-Oriented Teaching Design of Engineering Courses in Military Schools

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Abstract. In view of the current new requirements of the integrated training mode of military schools for course teaching design, we deeply analyze the implementation form of ability-oriented course design and its application in various subject areas. Based on this, we put forward a ability-oriented integrated course teaching design process, which includes three links: ability demand analysis, mapping model and course design. Besides, it also includes building a teaching model achieving a full-process assessment, case guidance, and a full-dimensional coverage.

Keywords: first-time qualifications · integrated course teaching design · QFD

1 Introduction

Recently, the military officer candidates in military schools adopt the integrated training mode of "first-time posts training major + undergraduate education major", which aims to cultivate first-time qualifications of military officer candidates by course teaching, which puts forward higher requirements for course teaching design. Especially for engineering courses, traditional teaching focuses on cultivating candidates' solid theoretical foundation. However, due to the lack of innovation and practical ability, it will take a long time to adapt to posts, which affects battle effectiveness. Therefore, it is necessary to take the new integrated training as an opportunity to carry out the teaching reform of engineering courses in military schools.

Compared with knowledge-oriented course design, ability-oriented course design reorganizes the teaching content, sets up the assessment mode, highlights the experiments and practice, by which teaching effectiveness are assessed. It aims to cultivate candidates' ability to analyze and solve practical problems by comprehensively applying knowledge.

On the basis of analyzing the main realization forms of ability-oriented course design and its application in various disciplines, this paper proposed a ability-oriented integrated course teaching design process.

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2 The Main Realization Form of Ability-Oriented Course Design

Ability, the skill-based knowledge, is a comprehensive manifestation of knowledge. It takes the comprehensiveness, flexibility and exploration of knowledge application as its core contents, that is, using knowledge to effectively solve practical problems. Compared with knowledge-oriented course design, ability-oriented course design reorganizes the teaching content, sets up the assessment mode, highlights the experiments and practice, by which teaching effectiveness are assessed. It aims to cultivate candidates' ability to analyze and solve practical problems by comprehensively applying knowledge. Ability-oriented course design which is not a new concept has been widely used in various disciplines and course design.

2.1 Progressive Implementation Approach [1, 2]

The single course shall be taught in a step-by-step and progressive way. There is an interactive process which involves interaction and cause-and-effect relationship between each teaching unit.This implementation approach adopts the method of a ladder structure, which the next step is deducted from the previous step: lesson preparation, teaching, practice and assessment. This teaching method ranges from simple to complex, with clear layers and coherence. The teaching goal is shifted from focusing on knowledge to focusing on ability, which conforms to the laws of people's cognition, so that the learning effect is improved.

From the perspective of the course system, it focuses on systematically cultivating candidates' comprehensive design ability and innovation ability, namely: establishment of practical methods in a vertical way, such as course experiments, course design and graduation design, establishment of the progressive frame structure in a horizontal way from cognition, verification to innovation.

2.2 Ways to Achieve Goal Traction [3]

It aims to design and organize course content and course practice from a comprehensive application and practice project. Teachers explain the relevant theoretical knowledge involved in each step of the comprehensive application and practice, and show the implementation effect of each step, so that candidates can clearly understand the status and role of the theoretical knowledge in the whole course. Moreover, candidates can also understand the functions and tasks that can be accomplished by taking part in the practical projects based on the theory. In this way, in the whole learning process, candidates are full of interest and enthusiasm for learning, which is in line with the logical sequence of candidates' understanding of problems. It is conducive to candidates' understanding of the knowledge structure of the course, and facilitates them to grasp the relationship between various knowledge points. It can avoid see the forest for the trees, enabling that the candidates who maintain a clear thinking got a good learning effect.

The teaching process includes five links: case introduction, teacher explanation, candidate explanation, candidate reflection and discussion, and experimental design and operation. The combination of teachers' "guidance" and candidates' active "learning"

stimulates candidates' enthusiasm and initiative, and cultivates candidates' ability to think independently and solve problems.

The experiment is divided into four levels: basic, comprehensive, design and innovative, which respectively cultivate candidates' basic skills, comprehensive design and innovation capabilities. Moreover, it manages students in groups by project management, requiring candidates to unite and cooperate with a good teamwork spirit.In this way, each module can be finished, realizing the expected function required by the experiment.

2.3 The Way to Realize Flipped Classroom [4, 5]

Flipped learning is the exchange of the original in-class teaching activities mainly based on "teachers' lectures" and the after-class learning activities mainly based on "candidates' assignments", showing the characteristics of individualization, diversification and free collaboration. The flipped classroom adopts a teaching model consisting of four links: experience integration, conceptual exploration, meaning construction and discussion application. Among them, experience integration and discussion application are carried out in class, while theme-related conceptual exploration and meaning construction are carried out by students after class. It can cultivate candidates' high-level abilities, and place the discussion and application of knowledge in the face-to-face classroom, so that the value of in-class teaching can be fully utilized.

From the perspective of course design, the flipped classroom is also a brand-new design: teaching content needs to be comprehensively evaluated, which content allows candidates to learn after class, which content needs to be properly explained in class, and which content needs to be focused in class; for teaching methods, both project-based and research-based teaching methods are required to be used. It is to organize candidates into several small teams, guided by projects, so as to cultivate candidates' engineering practice ability and teamwork ability; for teaching design, before the class, candidates are required to watch the teaching video, and then conduct guided exercises. During the class, candidates are required to complete a small number of quizzes as soon as possible, then complete the internalization of knowledge by solving problems, and finally summarize and give feedback.

Combining the three realization forms, it can be found that the ability-oriented course design needs to clarify the ability requirements of the courses. By decomposing and mapping the ability requirements to the course content and practical skills, we can optimize the course teaching design, highlight the candidates-centeredness, and enhance the candidates' autonomy and creativity.

3 The Application Characteristics of Ability-Oriented Course Design in Different Disciplines

From the perspective of course teaching design in different discipline, it also reflects different characteristics.

1. Economics and management courses [6]. When carrying out ability-oriented course design, we can transfer from "teaching-oriented" to "learning-oriented", and from "in-class teaching-oriented" to "combination of in and after class".

Specifically, the main methods include: allocating the content of teachers' lectures and candidates' self-study; introducing hot issues of current affairs, thereby overcoming the abstraction of the theory; using a method of process assessment: a combination of assignments, cases, project research, experimental design and group defense, etc.

2. Computer courses [7]. Aiming at the problems existing in traditional computer courses, we mainly adopt the course teaching system of "explaining algorithm ideas—enabling that candidates understand algorithm—using this algorithm to solve practical problems". The awareness of "algorithms are designed to solve practical problems" needs to be strengthened for candidates, who are also led to conduct algorithm analysis and design practice. Besides, we should emphasize the application of the online practice platform of programming and the programming competition platform, advocate teamwork, and highlight the cultivation of candidates' comprehensive practical ability and innovation ability.
3. Public basic courses such as mathematics and English [8, 9]. Public basic courses such as mathematics and English are designed and reformed in the aspects of innovation and critical thinking ability. For example, the case teaching method is introduced in mathematics, and mathematical modeling is integrated into university mathematics courses. College English teaching guided by the cultivation of critical thinking ability can not only improve candidates' English subject knowledge, but also help to improve candidates' comprehensive quality. In the course design, the cultivation of critical thinking ability is integrated into each teaching link.
4. Engineering courses [10]. Engineering education has earlier recognized that the goal of talent training should be shifted from the possession of knowledge to more emphasis on abilities, especially creativity training. Moreover, it needs to focus on innovative education. In the process of engineering course design, we enrich experimental teaching methods by simulation, virtual design, principle experiments, and innovative experiments; combined with subject competitions, some courses are designed to improve candidates' innovative ability and practical ability; we also cultivate candidates' awareness of civic responsibility and engineering practice ability through diversified learning; combining course teaching with industry-university-research cooperation, we are committed to exploring a new mode of talent training for industry-university-research cooperation.

Ability-oriented course design is applied in different types of courses, which have the following characteristics:

(1) Highlighting the candidates' ability goals, especially for the goals about how to practice and apply. Focusing on the cultivation of practical problem analysis and problem-solving ability;
(2) The course design takes a greater proportion in practice, competitions, cases, etc. It should be changed from passive acceptance to active creation and innovation;
(3) The course assessment has changed from a single knowledge assessment to a whole-process assessment, focusing on all aspects of theoretical mastery, skill training, and ability generation;

(4) The course design focuses on the guidance of candidates' learning drive, and stimulates candidates' inner desire by competition, hands-on activity, design, etc.

4 The Process of Ability-Oriented Integrated Course Teaching Design

Guided by the requirements of the first-time post and the military training syllabus, we design the training methods for each part, and build a full-process assessment, full-process case guidance, and full-dimensional coverage teaching mode based on the ability, knowledge, emotion, skill elements and course system clearly defined in the syllabus of engineering majors in military schools. We also build roadmaps and construction drawings for capability formation. As shown in Fig. 1.

Focusing on the process of ability formation, we use analytical tools such as causal diagrams, quality function deployment (QFD) to construct three ability formation routes: "ability-methods, principles, knowledge-teaching, reading, seminar", "ability-skills-experiments, training", "ability - attitude, emotion - course ideology and politics". Finally, a three-dimensional course teaching system is built.

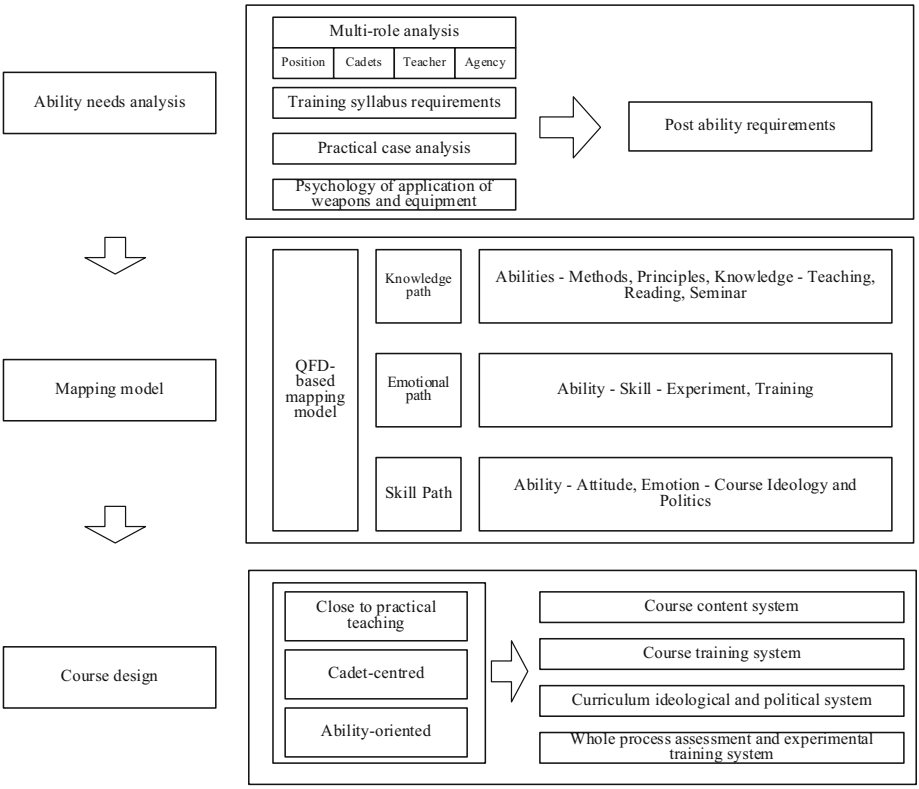

Fig. 1. The process of ability-oriented integrated course teaching design (self-drawn)

The process of ability-oriented integrated course teaching design mainly includes the following three stages:

4.1 Ability Needs Analysis

The engineering course ability of military schools is a collection of knowledge, skills and emotional elements related to weapons, equipment and related posts. By ability requirements, we analyze and refine the ability indicators of candidates' knowledge, skills, and emotions, providing detailed and accurate input for subsequent course design. The demand analysis adopts multi-perspective modeling and analysis methods, which conducts extensive research and questionnaire surveys from the aspects of the army's post demand, the candidates' career development demand, the instructor's training demand and the needs of all levels of government agencies; at the same time, we further deepen the relevant knowledge and skills related to the use of weapons and equipment in combination with the requirements of the military training outline and practical application cases in war; considering the psychological quality requirements for people using weapons and equipment, we fully consider the emotional, ideological and political needs of candidates during class. Specifically, it can be combined with the cause and effect diagram to continuously refine knowledge, skills, emotions, and clarify the ability needs.

4.2 QFD-Based Knowledge, Skills, Emotion Mapping Model

Quality Function Deployment (QFD) is a systematic method that, by multi-level logical deductive analysis, it gradually transforms the voice of customers into the engineering characteristics of the product development process. It is market-oriented and based on customer needs. Moreover, it provides a comprehensive guarantee of product suitability in the early stages of product development. The QFD process is done through a series of charts and matrices.

As shown in Fig. 2, the QFD-based course mapping model is divided into four parts:

(1) Extraction of the requirements for the use of weapons and equipment. On the basis of sufficient research, we sort out and extract the demand items by KJ method, and then repeatedly analyze and merge the demand items by Quantification Method of type III, finally extract the candidates' post ability requirements.
(2) The extraction of teaching objectives, that is, on the basis of the first step, the language of post ability requirements needs to be transformed into course teaching objectives, and a teaching quality design house needs to be established.
(3) According to the extraction of the elements of the course training objectives, that is, based on the teaching objectives, we analyze and obtain the course training design objectives and requirements combined with the course knowledge network structure.
(4) Taking the training objectives as the traction, we refine the training measures and methods of the course in accordance with the three dimensions of knowledge, emotion and skills related to the formation of the course ability. It ensures that the quality of the course teaching meets the requirements of the battle effectiveness of the army.

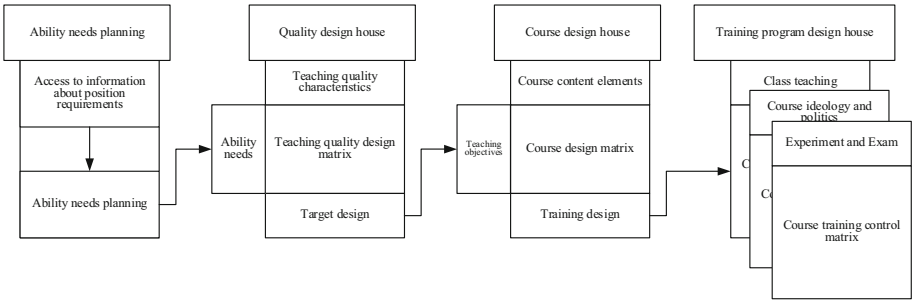

Fig. 2. QFD-based Course Teaching Design Mapping Model (self-drawn)

4.3 Ability-Oriented Course Design

According to the results of the QFD mapping model, four systems are formed: course content system, course training system, course ideological and political system, and whole-process assessment and experimental training system.

(1) Course content system. We refine the content system by mind map, clarifying the standards of each part, and building a case material library related to the course content.
(2) Course training system. We distinguish training methods such as theoretical teaching courses, seminars and practical courses, and online micro-courses according to the nature and characteristics of the teaching content. Finally, a mapping table of course content-training methods is formed.
(3) Course ideological and political system. Based on the characteristics of the engineering courses in military schools, course ideological and political system focuses on cultivating candidates' firm belief and perseverance, as well as the fighting spirit of learning for war and practicing for war.
(4) The whole process assessment and experimental training system. Based on the characteristics of the course content, we integrates after-school homework, in-class testing, course design experiments, and weapon and equipment operation skills training into the course training, among which some with commonality can also be combined with competitions and tournament.

5 Evaluation of Ability-Oriented Integrated Course Teaching Design

To make the teaching of engineering courses in military schools reach the predetermined goals, it is necessary to design a series of evaluation standards according to the elements of personnel training objectives. It aims to implement control over them, and form a closed-loop control process for continuous optimization of course teaching, for which a control matrix is constructed. According to the three modules of course design, teaching resources and teaching management, we design three teaching design quality control

Table 1. Control matrix of teaching management module (self-drawn)

	Evaluation elements	Control mode				
		Implementer	Assessment contents	Evaluation methods	Evaluators	Time of evaluation
Teaching management	Teaching management in class	Teacher	Teaching quality evaluation standard system	Qualitative scoring	Student/Teaching management department	End of course / during implementation
	Training practice management	Student Teacher	Training practice evaluation system	Combining qualitative and quantitative	Student/Teacher/Teaching administration	End of course/End of training practice/Before class
	Assessment management	Student Teacher	Assessment and evaluation index system	Combining qualitative and quantitative	Teaching administration	End of course
	Ability generation management	Student	Ability evaluation index system	Combining qualitative and quantitative	Teaching management department/army/government agency	Graduation assessment/Troop training assessment

matrices respectively. The following is only the control matrix of teaching management module, as shown in Table 1.

Teaching management is evaluated from four aspects: course teaching management, training practice management, assessment management and ability generation management. The evaluators, including students, teaching management departments, army and government agency make a conclusion by a combination of qualitative and quantitative methods. Through evaluation, we optimize course training design and adjust the three ability formation routes of knowledge, skills and emotion.

The ability-oriented integrated course teaching design process has been applied in 10 courses of the 3 different engineering disciplines. The evaluation result shows that the degree of satisfaction of student, teaching administration department and army respectively improved 32.12%, 27.22% and 31.08%.

6 Conclusion

The new integrated training mode of military schools make new request for course teaching design. During developing high-quality engineering courses, the research puts forward the process of ability-oriented integrated course teaching design. That is, through multi-dimensional perspective analysis of ability requirements, we carry out ability mapping of course teaching by QFD, and construct four systems based on mapping results: course content, course training, course ideological and political system, course whole-process assessment and experimental training. Finally, a three-dimensional course teaching system is built.

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