

# A Research on Application of Blended Learning Mode in the Teaching Reform of Theory of Missile Guidance and Control

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**Abstract:** Considering theory-focused and relatively dull content of Theory of Missile Guidance and Control, and the low learning motivation and weak practical skills of the students, this paper describes the practice and experience of blended teaching reform in the course. A comprehensive analysis was done on real demands of students' ability, the nature of the course and characteristics of content. The teaching idea of building a solid foundation, emphasizing on the operation of the equipment, actual combat, and the development of equipment was applied. In order to improve the students' abilities and their understanding of the subjects, a new blended teaching mode for the theoretical course of equipment was explored, so as to form an evolving cycle of "theoretical study, hands-on practical, and forming new abilities," spark the students' interest in learning, and cultivate new thoughts in autonomous learning and innovative practice. This teaching mode has been practiced for a few years and is shown to be effective in improving the ability of students and the quality of training for personnel of military technology. Therefore, it can be used as a reference for curriculum reform of courses involving equipment.

**Keywords:** Blended; Teaching mode; Course reform; Guidance and control

**Online publication:** October 26, 2022

## 1. Introduction

With the rapid development of network and multimedia technology, information technology have been more and more widely used in teaching<sup>[1-2]</sup>. The online courses constructed by the government, colleges, and universities provide a good platform for students to study independently<sup>[3-4]</sup>. In traditional teaching, more focus is placed on the teachers' teaching and downplays students' independent learning which has been a great challenge to be overcome<sup>[5-6]</sup>. Blended teaching combines the advantages of both traditional classroom teaching and online learning, which has in away make up for the deficiencies of simple face-to-face courses and simple online teaching. At the same time, this mode fully reflects the initiative, enthusiasm and creativity of students as the main body of the learning process, and can better improve the learning ability of students<sup>[7-9]</sup>. Therefore, the teaching team to which the author belongs to takes the Theory of Missile Guidance and Control as the pilot course and adopts the blended teaching mode to carry out the course reform.

Theory of Missile Guidance and Control is a required course for undergraduate majoring in Missile Measurement and Control Engineering, which is the theoretical basis of navigation guidance and control, aerospace defense system engineering and other disciplines. This course closely focuses on guidance and control technology, the core missile technology that ultimately result in combat effectiveness in the air

defense missile. The course involves fluid mechanics, flight mechanics, control theory, guidance technology and other contents, requiring students to have a profound theoretical foundation of mathematics and physics<sup>[1]</sup>. In the past, because of the relatively dull course content, with too much mathematical theory derivation, students have low interest in learning and are unenthusiastic, and the effect of learning is not ideal. At the same time, the theory teaching is not well-connected to the use of equipment, resulting in the students' low ability in analyzing and solving practical problems of different equipment. These problems seriously restrict the effect of practical lessons and hampers the improvement of training quality of equipment personnel in the new era. Based on the existing problem in the teaching of this course, our team designed a military course with high quality. Our team took the opportunity to carried out the reform of blended teaching mode in Shaanxi Province. In view of the urgent needs of practical personnel training and military post capacity, we vigorously strengthened the comprehensive construction of the course, dynamically updated the teaching content, perfected the supporting teaching resources, optimized the teaching methods and means, actively explored the application of blended teaching mode in Theory of Missile Guidance and Control, and changed the traditional teaching mode. After implementing this new teaching mode for nearly five years, a positive effect was achieved.

## **2. Highlight the main position of students, and reasonably choose teaching methods and means**

In the teaching process, in view of the course involving many concepts, being very theoretical, and the need for improving students' ability in operating different equipment, we applied the teaching idea of "solid foundation, and emphasizing on equipment, actual combat, and development of equipment." We closely integrated the development of new air defense and missile defense equipment, centering on the innovation of curriculum teaching mode, optimizing teaching content continuously, and meeting the "four characteristics" (pertinence, systematization, practicability and effectiveness) of curriculum teaching. The innovation of teaching methods and means of "multi-form combination, multi-method synthesis and multi-means combination" was used as the starting point, and the reform of curriculum teaching assessment and evaluation mechanism acted as the foothold. The linkage reform was carried out around the core elements of curriculum reform, and the construction of a new curriculum teaching mode with distinctive characteristics and high application efficiency was explored.

### **2.1. Regard learning as the main body.**

The principal position of students was strengthened and their awareness of innovation and independent learning ability were raised. In the teaching process, the concept of "determine the learning objectives, find out difficulties, experience self-directed learning, construct the cognitive structure of independent study, learn to conduct self-assessment," was applied, so as to fully arouse interest and motivation in learning. A closed loop of teaching through "goal guidance – difficulty analysis – self-learning – self-evaluation" was formed, so as to change the mindset of students from "learning because they are asked to" to learning willingly.

### **2.2. Enrich teaching means.**

Combined with the specific teaching content, diversified teaching methods were adopted to improve the classroom teaching effect. By using the advantages of information technology, the dynamic characteristics of missile guidance and control system were demonstrated through animation. The doubts and difficulties faced students while they are self-studying were resolved through online communication during the online classes. Through the collection and analysis of different cases, the students' enthusiasm for learning was stimulated, and the combination of technology, equipment and operations is completed. Through the experiment and practice of combining all kinds of virtual software and actual equipment, it helps students

analyze the characteristics of all kinds of guidance and control methods, and helps in cultivating students' scientific literacy. Through the revolutionized classroom teaching, part of the learning process was done outside the classroom, so as to make full use of the classroom time for positive interaction, in-depth learning, and to stimulate students' independent and innovative thinking abilities. Through rational use of a variety of teaching means, learning was made more fun, and the initiative of students for learning were stimulated.

### **2.3. Reasonable use of teaching methods**

“Five-star” teaching method, contrastive teaching method, inquiry-based teaching method, problem-based teaching method, heuristic teaching method, case teaching method, project teaching method and other teaching methods were used comprehensively. Contrastive teaching method was mainly applied in the teaching of different guidance methods, guidance systems and control methods, which helped in avoiding confusion through pointing out differences. Inquiry-based teaching method was implemented in small groups. Principles were analyzed layer by layer in order to understand the essence of guidance and control theory. Problem-based teaching method is mainly used in explaining concepts, working processes and working principles of various guidance laws and guidance control methods. Through the idea of setting the problem by analyzing concepts and elements, eliciting the problem by analyzing working process, and solving the problem by analyzing working principles, different problem chains are formed and a knowledge system is constructed. The teaching methods should be adopted reasonably according to the characteristics of different contents, and the diversity of teaching methods should be increased.

### **2.4. Using the teaching effect to evaluate the blended teaching mode**

In order to better test the teaching effect, seven modules including network self-study module before class, self-test module of exercises before class, discussion or forum module before class, classroom activity participation module, teaching content test module, completion module of homework after class, mutual evaluation and self-evaluation module were used to generate real-time statistics of students' learning dynamics, grasp the learning effect of students in time, and give play to the leading role of teachers in guiding, inspiring and monitoring the teaching process. Through online and offline Q&A, in-class and out-of-class guidance, theoretical analysis and experimental operation, etc., the teaching shortcomings were made up for and the teaching effect was improved. Moreover, through questionnaire surveys and the surveys done on the military, the feedback results of teaching effect on the abilities on military personnel of the were understood. Improvements were made after analyzing the feedback on the effect of the new teaching mode.

The teaching team adhered to the teaching concept of “learning as the main body and teaching as the guide,” and adopted a variety of teaching methods and means by combining specific teaching contents, so as to stimulate learning interest and improve learning effect. The teaching methods were further optimized through collecting and analyzing feedbacks, further enhancing the “teacher teaching-student learning-teaching inspection-teaching reform” link, and provide a basis for curriculum teaching innovation and practice.

### **3. Focus on the demands of equipment support ability, and explore and practice the teaching mode of “combining three practical ways of teaching and four combinations”**

The course closely focuses on the guidance and control theory of surface to air missile, which is the core of the technical support of surface to air missile force, and also the key to form combat effectiveness of air missile weapon system. In order to develop the students' ability in certain military positions, operate and analyze and solve practical problems, the teaching team put forward the blended teaching mode of three practical ways of teaching and four combinations. Three practical ways means starting from the actual

combat needs of troops, relying on actual equipment, using experimental technology as means, and using actual cases for teaching. Four combinations mean combination of online teaching and offline teaching, combination of software and hardware, combination of virtuality and reality, and combination of in-class learning and out-of-class learning. Through this kind of blended teaching mode, the application characteristics and professional characteristics of surface to air missile weapons are highlighted, the latest scientific research results are introduced into the teaching timely, and the teaching is combined with the real armament, so as to increase the students' perceptual understanding and intuitive experience.

### **3.1. Three practical ways of teaching**

#### **(1) Real equipment**

The "Theory of Missile Guidance and Control" course involves many types of missiles and has a clear background of theoretical engineering application. In the course of teaching, specific types of equipment are combined to carry out teaching, which gives students an intuitive impression. For example, in the teaching process of different guidance systems, such as remote-control guidance and homing guidance, basic working principles were taught using real missile components; guidance and control signal flow was taught in combination with the missile's internal structure, and core components and electronic circuits were clearly described. The influence of guidance and control system on weapon system performance index was analyzed to strengthen the connection between theoretical learning and practical equipment application.

#### **(2) Experiments**

In view of the characteristic of theory of missile guidance and control, and the big difference between different guidance methods and control methods in experimental phenomenon, experiment teaching needs to be carried out. Students set experimental conditions under the guidance of the instructors, carry out the required experiments and record their observations. The instructor leads the students to explore the nature of the experiments, step by step, and summarizes the characteristics of different guidance and control methods. Through the experimental teaching, the students' hands-on programming ability and simulation analysis ability are cultivated, which lays a foundation for the learning of equipment theory.

#### **(3) Real cases**

Real case teaching refers to the use of actual cases of target shooting and equipment maintenance & support. Learning is improved by compiling and selecting the equipment failure and combat cases related to guidance and control, which are authentic, complete, typical and enlightening, and connecting them closely with the course content, the pertinence and effectiveness of guidance and control principle. The problem-solving skills of students are developed through observations in of practical cases, performing and in-depth analysis of the experimental results relating to the principle.

### **3.2. Four combinations**

#### **(1) Combination of online teaching and offline teaching**

In the informationized teaching environment, online teaching and offline teaching are deeply integrated. Classroom teaching is organized according to three links: before class, during class and after class <sup>[10]</sup>. Before class, with the help of the online teaching platform and the school's key curriculum construction platform, teaching tasks are released in advance, teaching materials are uploaded, and preview guides are provided. Teachers then make classroom teaching plans according to the students' preview conditions. Then, targeted teaching is carried out according to the students' preview situation, and a variety of teaching methods are utilized to break through the key and difficult content. After class, students finish their homework, and conduct online evaluation and course preview on the network

teaching platform. Through the combination of online and offline methods, students' autonomous learning ability can be cultivated and teaching efficiency can be improved <sup>[11]</sup>.

(2) Combination of software and hardware

Software resources such as “auxiliary demonstration platform for guidance and control system,” “classical guidance rule platform” and “missile electric steering gear control system” were introduced into classroom teaching. Software simulation provides a platform for the performance analysis of guidance rules and control rules, provides an analysis tool for students to distinguish the performance of different guidance methods and control methods, and lays a foundation for in-depth understanding of guidance and control theory. The actual equipment, such as the missile rudder system and seeker system, can reproduce the combat state of the missile through the setting of software parameters, which can provide intuitive impression for students to understand the working principle of the guidance and control loop under different guidance systems. Through the combination of software and hardware, the students' ability to form good programming and equipment operation are developed.

(3) Combination of virtual simulation and reality

Considering that the number of actual missile equipment in the main campus of the school is limited, the virtual equipment in the simulation training center should be fully utilized, and the teaching mode of combination of virtual and reality is adopted, which is “from the real-life to virtual, from virtual to real-life, and get familiar with the real-life + virtual mode.” In the case of practical installation, the instructor verifies the relevant guidance and control theory, so that the students can understand the application of principles. When there is no practical installation, the simulator is used for verification and analysis to master the practical engineering application of guidance and control theory. Through the combination of virtual simulation and real-life practical installation, the students can master the basic theory of surface to air missile guidance and control.

(4) Combination of in-class learning and out-of-class learning

The students' extracurricular time, scientific and technological innovation, military practice, comprehensive drill, live firing and other activities will be combined with in-class teaching, carefully organized and arranged, and the maximum support and help will be provided to the students in terms of venues, instruments and equipment. Build a “learning as the main body and teaching as the guide” ability generation platform and open experimental platform, encourage students to learn through online resources by using extracurricular time, and find out any misunderstanding they have about the topics, and have their questions resolved during the lessons. At the same time, extracurricular scientific and technological innovation needs to be regarded as an extension of in-class teaching, carrying out some high-level research experiments. In this way, the students' autonomous learning ability and hands-on ability can be developed.

#### **4. Strengthening of the links of operation and practice, and all-round consolidation of students' ability base**

Practical operation is an important way for students to improve theoretical cognition, which can effectively stimulate innovation and develop practical ability <sup>[12]</sup>. Course teaching includes observation, cases, independent experiments, project introduction, program design, equipment demonstration and other diverse teaching activities. Students can have direct knowledge and understanding of the working principle of the missile guidance and control system, which is conducive to the close combination of the guidance and control theory with the application of weapons and equipment. The application of course teaching is mainly reflected in the four following aspects:

(1) Actual equipment application practice

According to different guidance systems, combined with specific missile equipment components and electronic wall charts, the circuit structure and working principle of guidance and control system are explained in practice. By inputting instructions, setting parameters and changing conditions, the students can drive the rudder system, seeker system and other equipment to work in real time, intuitively feel the working process of the missile guidance and control system, and further understand the basic theory of guidance and control.

(2) Participating in the practice of scientific research projects

Curriculum teaching team can introduce the research projects, such as the national natural science funds, aviation funds, weapons and equipment pre-research project, into course teaching. The guidance and control theories and methods closely related to the teaching content of the course can be selected to condense the small topics suitable for undergraduate students, and clarify the research background, technical route and research objectives. Through the introduction of the project teaching, high-quality teaching objectives can be achieved, algorithm design ability and simulation analysis ability of students can be improved, good scientific literacy and rigorous scientific attitude of students can be cultivated, and independent innovation ability of students can be stimulated.

(3) Experimental operation practice

The course is set up with 6 simulation experiments. The characteristics of classic guidance and control algorithms can be analyzed by using the simulation platform of all-digital guidance and control system, and suggestions for algorithm improvement can be put forward. By using the guidance control loop hardware-in-the-loop simulation platform, the influence of the guidance parameters on the output of the equipment is analyzed. Through the organic combination of these software and hardware systems, the students can improve their understanding of the working principle of the seeker, steering gear and other equipment in the guidance and control system, cultivate their software and hardware application ability, and improve their practical ability and analytical ability.

(4) Case teaching practice

Through real cases such as target shooting and missile failure, students are guided to explore the essence behind the surface phenomenon of cases. Through in-depth analysis, students can make clear the influence of guidance and control system on the whole missile operation process, and learn to use the guidance and control theory to analyze problems in the case. Through case-based teaching, students are encouraged to learn independently and actively, and is able to master the methods of analyzing and solving problems, and enhance the predictability of future work.

## 5. Application and practical effect

In the process of curriculum reform practice, by updating the teaching idea, the teaching mode “three practical ways of teaching and four combinations” effectively expand the depth of teaching about the Missile Guidance and Control Theory, so as to inspire the students learning interest and enthusiasm, significantly improve the students’ ability of meeting their job requirements and quality, and improve the quality and efficiency of equipment principle teaching. This course provides strong support for subsequent equipment operation courses. Students can flexibly combine basic theories with practical equipment, laying a solid foundation for equipment troubleshooting.

Since the blended teaching mode was adopted in the course of Theory of Missile Guidance and Control in 2016, satisfaction rate of student has increased from 63.5% to 91.6%. The statistical results show that in the past five years, the pass rate, good rate and excellent rate of students’ examination results have been greatly improved, and the quality of teaching and the level of students' knowledge and ability have been significantly improved. The improvement of course teaching effect has laid a good foundation for subsequent equipment operation courses, and the maintenance and support ability of missile guidance and

control system has also been greatly improved. At the same time, this course has set up innovative practice activities for students, which greatly stimulates the students' creativity and enthusiasm, and improves the students' ability to take initiative. Students actively participate in the National Robot Competition, China Education Robot Competition, Electronic Design Competition, China Computer Game Competition, and various national hardware and software competitions. In the past five years, students who attended this course have won 16 national special prizes, 37 first prizes and 62 runner-up prizes, which further verifies the effectiveness of the teaching mode.

At present, the reform of blended teaching mode based on the combination of "three practical ways of teaching and four combinations" has become a bright spot in the course construction of equipment principle of missile measurement and control engineering specialty, which has greatly improved the level of curriculum and discipline construction. Since 2016, the course has been rated as the top construction course of the university and the top construction course of Shaanxi Province. The Measurement and Control Engineering major has been successfully approved as the provincial pilot professional comprehensive reform project, and the course teaching team has been awarded the Provincial Teaching Team of Universities in Shaanxi Province. In the past five years, the teaching team members have won more than 10 prizes, such as Provincial First Prize, School First Prize, School Runner-up Prize, and Teaching Achievement First Prize. The demonstrative course designed based on the blended teaching mode won the national second prize in the National Vocational Education Information Teaching Competition in 2017 and the first prize in the Provincial Classroom Innovation Competition in 2020, which was unanimously recognized and praised by experts.

## **6. Conclusion**

The reform of course teaching mode is a systematic and long-term work, which should be targeted at the abilities needed for military posts. The law of talent development needs to be followed based on the current situation of software and hardware teaching guarantee in schools, the characteristics of students' knowledge and needs need to be taken into account. Through the reform of blended teaching mode, the initiative of students should be brought into full play, and should be fully mobilized to change passive learning into active participation. At the same time, through the reform, it has strengthened the communication and training of teachers, guided and encouraged young teachers to devote themselves to teaching and actively participate in teaching research and reform, therefore greatly improving the quality of the teaching team. Therefore, as a continuous innovation of classroom teaching, the reform of blended teaching mode can provide students with services beyond the existing education and teaching system, and can also provide more room for the development of teaching team. Exploring the application of blended teaching mode of "three practical ways of teaching and four combinations" in the course of Theory of Missile Guidance and Control can provide reference for the teaching of other equipment principles. In the future, the teaching team will further study the application of blended teaching mode based on the full network coverage environment constructed by the school, utilize modern information technology, combine development of online course of the Theory of Missile Guidance and Control, and explore new methods and ideas of reform dominated by teaching effects.

## **Disclosure statement**

The authors declare no conflict of interest.

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