

Design and Application of Case Teaching in Satellite Navigation Professional Education

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Abstract. Addressing the tension between the rapid advancement of satellite navigation technology and the growing demand for specialized talent, this study focuses on the distinctive features of professional education and thoroughly explores the core value and systematic implementation pathways of case-based teaching in satellite navigation professional education. The research begins by elaborating on the strategic significance of satellite navigation systems in both military and civilian domains and the urgency of talent development, while examining the goal-oriented and practice-driven nature of professional education. Building on this foundation, a comprehensive case teaching framework for satellite navigation professional education is proposed, covering the entire process of "case database development – teaching implementation – effectiveness evaluation." The study details strategies for integrating case studies into classroom instruction, simulation exercises, and collaborative reflection, as well as methods for assessing teaching outcomes. Through systematic case teaching practices, this study aims to enhance students' job readiness, complex problem-solving skills, and tactical decision-making capabilities, thereby providing robust support for cultivating high-quality, application-oriented, and innovative talent in the field of satellite navigation.

Keywords: Satellite navigation; Professional education; Case-based teaching; Instructional design; Competency development; Educational reform.

1. Introduction

Since its inception, satellite navigation technology has played an indispensable role in both military and civilian fields and continues to evolve rapidly. The deepening application of satellite navigation systems urgently requires strengthening the cultivation of professional talent in satellite navigation. Currently, professional education in satellite navigation is the main pathway for cultivating such talent. However, there exist problems such as copying the academic education model, resulting in mismatches between teaching philosophy, content, level, methods and the needs of professional education [1]. Aiming at the requirements of satellite navigation professional education and considering its characteristics, this paper analyzes teaching methods suitable for satellite navigation professional education, focusing on case-based teaching. It discusses three aspects: case construction, teaching implementation, and evaluation feedback, constructing a case teaching system covering "case database construction - teaching implementation - effectiveness evaluation" to enhance the teaching effectiveness of satellite navigation professional education.

2. Strategic Position of Satellite Navigation and Urgent Need for Talent Cultivation

2.1 Current Development and Strategic Position of Satellite Navigation

Currently, the world has formed a pattern of four major navigation systems: China's BeiDou Navigation Satellite System (BDS), the United States' Global Positioning System (GPS), Russia's GLONASS, and the European Union's Galileo. Satellite navigation technology is undergoing a profound transformation from single Positioning, Navigation, and Timing (PNT) services to diversified, high-precision, high-reliability, and high-security services such as PNT+ communication, short message, satellite-based augmentation, precise point positioning, and international search and rescue. Its deep integration with 5G, the Internet of Things, artificial intelligence, remote sensing and other technologies has spawned massive emerging application scenarios including autonomous driving, precision agriculture, smart cities, and disaster prevention and mitigation, profoundly reshaping socio-economic operation modes and national security postures [2].

In the civilian domain, satellite navigation has become the spatiotemporal benchmark for national critical information infrastructure, deeply embedded in all aspects of production and life, providing foundational support in transportation, public security, energy and power, finance and communications, agriculture, forestry and fisheries, resource exploration, and mass consumer applications. In the military domain, satellite navigation systems serve as vital support for modern information warfare [3], providing all-weather, round-the-clock, high-precision battlefield spatiotemporal information support for precision strikes, personnel positioning and navigation, battlefield situational awareness, command and control coordination, unmanned platform operations, search and rescue, etc., directly affecting combat effectiveness and national security. It is a key element in seizing battlefield information superiority.

2.2 Urgency of Developing Satellite Navigation Professional Education

With the widespread application of the BeiDou-3 global system, the demand for satellite navigation professionals has become more urgent and quality requirements higher. There is an urgent need to accelerate the cultivation of satellite navigation professionals with a solid theoretical foundation, outstanding complex engineering problem-solving abilities, and refined job-specific skills. Therefore, vigorously developing professional education centered on capability generation and closely aligned with job requirements to cultivate satellite navigation professionals has become a crucial measure for maximizing the effectiveness of BeiDou applications.

3. Orientation and Characteristics of Professional Education

3.1 Core Features and Requirements

Compared with academic education, professional education focuses more on cultivating job competency, with more specific and practical teaching content and a relatively shorter teaching cycle, enabling rapid improvement of students' job skills. Its features include: (1) Strong relevance: closely centered around job requirements, with teaching content, methods, and approaches designed according to the characteristics and needs of specific positions, directly meeting students' job needs. (2) Strong practicality: emphasizes practical teaching through case analysis, simulation training, field visits, on-the-job internships, and other forms, enabling students to master job skills in practice and improve their ability to solve practical problems. (3) Strong timeliness: as social development and job requirements change, the content and methods of professional education can be updated and adjusted promptly, ensuring that what students learn aligns with contemporary development and job demands. (4) High flexibility: various flexible teaching formats, such as intensive training,

distributed learning, and online learning, can be adopted based on students' actual situations and needs, facilitating learning.

3.2 Specific Requirements of Satellite Navigation Professional Education

The core requirements of satellite navigation professional education are particularly prominent in the following dimensions:

Table 1. Core requirements of satellite navigation professional education

Characteristic Dimension	Academic Education	Professional Education	Specific Requirements for Satellite Navigation Professional Education
Training Objective	Lay disciplinary foundation, cultivate general abilities	Focus on job competency, cultivate specific professional abilities	Precisely align with R&D, operation, maintenance, management positions
Content Selection	Systematic, emphasis on disciplinary theoretical framework	Targeted, emphasis on job knowledge, skills and applications	Highlight navigation principle application, system operation, troubleshooting, safety management
Teaching Focus	Knowledge delivery and theoretical system construction	Competency training and practical problem solving	Emphasize hands-on operation, case analysis, solution formulation, emergency response
Knowledge Timeliness	Relatively stable	Requires rapid update, keep pace with technology and job evolution	Must integrate latest technologies, application models
Teaching Methods	Lectures, experiments primarily	Diversified: case-based teaching, simulation exercises, project practice, seminars mainly	Case teaching becomes core vehicle
Evaluation Criteria	Focus on knowledge mastery and examinations	Focus on competency achievement and job performance simulation	Assess ability to solve practical navigation problems, operational proficiency, decision-making level
Student Background	Relatively homogeneous knowledge level	Diverse experiential backgrounds, personalized needs	Must accommodate differentiated needs of students at different job levels

As shown in Table 1, there are significant differences between academic education and professional education in satellite navigation across various dimensions. The educational philosophy, content, and methods of traditional academic education are not fully applicable to professional education. Therefore, educational approaches better suited to the needs of satellite navigation professional education need to be explored. Case-based teaching, with its advantages of high participation, strong practicality, relevance, and timeliness, is highly compatible with the requirements of satellite navigation professional education and can serve as an important method for such education.

4. Case Teaching: Core Method Aligned with the Needs of Satellite Navigation Professional Education

Case teaching, as a teaching method that links theory with practice, is widely used in education [5]. Using real cases as carriers, it combines abstract theoretical knowledge with practical problems, stimulating students' learning interest and making them more actively engaged in the teaching process [6]. Cases mostly originate from real events in actual work; through the learning process, students accumulate certain practical experience, improve their ability to analyze and solve practical

problems, and lay a solid foundation for future job performance. Case teaching can select appropriate cases according to different teaching objectives and students' actual situations, keeping pace with current events, making teaching more relevant, integrating cutting-edge technology, and enhancing teaching effectiveness.

The above characteristics of case teaching align well with the needs of satellite navigation professional education. First, case teaching highly matches the practical requirements of cultivating satellite navigation professionals: cases are microcosms of practice, well-suited to the core goal of "competency training and practical problem solving" in professional education. Operational procedures, troubleshooting, system integration, and other aspects in the navigation field can be vividly presented through cases. Second, case teaching effectively conveys complex technical applications of satellite navigation systems; navigation technology application scenarios are complex and variable (e.g., environmental influences, interference, multi-system integration). Case teaching can explain technical principles in specific application contexts, helping students understand the roles and limitations of technology in real environments. Third, case teaching can simulate actual environment and information uncertainty, effectively honing students' analytical judgment and rapid decision-making abilities, which are core requirements of professional education. Finally, case teaching facilitates experience exchange and tacit knowledge transfer; students come from different units and positions with diverse experiences, and case discussions become an effective platform for sharing practical wisdom and discussing challenging problems. Therefore, case teaching is a key tool for improving the effectiveness of satellite navigation professional education. By constructing a case teaching system covering "case database construction - teaching implementation - effectiveness evaluation" and carrying out satellite navigation professional education, the advantages of case teaching can be fully utilized to improve teaching outcomes.

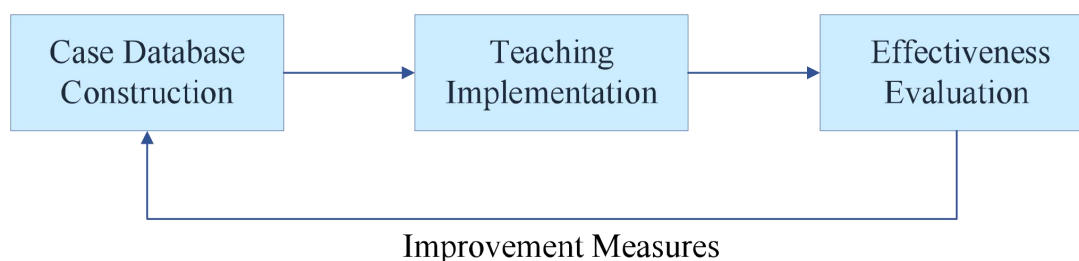


Fig. 1 Satellite Navigation Professional Education Case Teaching System Framework Diagram

In this system, systematic and high-quality case database construction is the fundamental prerequisite. Sources must be broadened and quality strictly controlled to ensure authenticity, typicality, and teaching relevance of cases, carefully constructing a structurally complete, richly connotative, and challenging case database. Adversarial teaching implementation is key: cases should be deeply integrated into classroom lectures, thematic seminars, simulation exercises/practical operations, assessment and evaluation, etc., flexibly utilizing various forms such as group discussions, role-playing, debates, scenario assignments, giving full play to their bridging and catalyzing role. Multi-dimensional, accurate, and effective effectiveness evaluation is a guarantee; a multi-dimensional, whole-process evaluation system must be established, with evaluation results used for student feedback, teacher reflection, case database updates, and continuous teaching improvement.

4.1 Systematic Construction of the Case Database for Satellite Navigation Professional Education

4.1.1 Core Principles of Case Design

Case design follows these key principles: 1) Authenticity: Cases must originate from real application scenarios to ensure credibility, allowing students to perceive the complexity and

challenges of actual work. 2) Relevance: Closely focus on teaching objectives and students' job requirements, designing cases of different types and difficulty levels. 3) Typicality: Reflect common problems and typical situations in the satellite navigation field, enabling students to master solutions for similar problems and develop the ability to draw inferences. 4) Inspirational value: Design should stimulate students' thinking and desire for exploration, possibly setting up suspense or questions to cultivate innovative thinking and problem-solving abilities. 5) Comprehensiveness: Should cover multiple knowledge points and skill areas, promoting students' integrated understanding and enhancing comprehensive application ability. 6) Timeliness: Should reflect the latest developments and cutting-edge applications in satellite navigation technology, with timely updates to the case database.

4.1.2 Systematic Compilation of Case Resources

Case resources should cover the entire R&D and application process of satellite navigation as well as the full signal processing chain, meeting the needs of personnel in different positions. Case sources include: 1) Summaries of navigation system construction experience: based on practical engineering experience of the institution, summarizing good practices and existing problems to form relevant cases, including model development and testing process cases, system integration and acceptance cases, user application feedback cases, etc. 2) Extraction from work tasks: selecting representative tasks related to satellite navigation in which the institution participates and condensing them into cases, including environment simulation cases, navigation deduction cases, test and evaluation cases, etc. 3) Organization and analysis of public resources: extensively collecting domestic and international information on cutting-edge satellite navigation technologies and system applications, conducting in-depth analysis, and organizing them into cases, including public accident and incident analysis cases, academic and industrial report analysis cases, etc. After collection, cases are screened and organized, removing redundancy, extracting key issues and core content to ensure cases are concise, clear, and easy to learn and analyze.

4.1.3 Elements of Case Design

Case design elements include case title, abstract, main content, key questions, etc. The case title should clearly reflect the core content; the abstract should outline the case background, core problem, and learning objectives; the main content should describe in detail the development process, technical details, available information, difficulties and conflicts encountered; key questions explicitly raise the core issues that students need to analyze and solve or decisions to be made.

Table 2. Case elements requirements

Element	Function	Design Key Points
Title	Pinpoint the contradiction	Include "scenario + conflict" keywords
Abstract	Understand case overview	Three elements: background, problem, objective
Technical details	Construct decision-making environment	Geographic environment (terrain/weather), mission attributes (rescue/survey), equipment configuration (device model/network status)
Difficulties & conflicts	Trigger problem-solving	Describe abnormal phenomena, immediate consequences, resolution time
Available information	Provide analytical basis	Raw observations (pseudorange/carrier phase diagrams), equipment status (battery/temperature), environmental parameters
Constraints	Simulate real limitations	Time, resource requirements
Core questions	Link theoretical system	Technical principles
Decision-making	Train comprehensive judgment	Provide mutually exclusive alternatives such as technical paths, resource allocation

4.2 Deep Application of Case Teaching in Satellite Navigation Professional Education

Case teaching is organized and implemented in three stages: pre-class, in-class, and post-class [6].

1. Pre-class preparation: Design the teaching process based on the case, including course introduction, principle explanation, knowledge connection, etc. Anticipate students' possible reactions to the case, sort out potential questions, and prepare thoroughly. Case materials can be distributed in advance for students to read and conduct preliminary analysis, forming personal opinions.

2. In-class seminar: Emphasize students' active participation, using a "group discussion + adversarial exercise" format. Group discussion: Students are divided into groups to discuss core issues of the case in depth, share perspectives, exchange ideas, and attempt to formulate solutions. Each group reports discussion results and engages in debates. Adversarial exercise: In cases involving command decisions and multi-party coordination, students play different roles, discussing and making decisions based on their role positions, enhancing situational immersion and empathy. The instructor primarily acts as a facilitator, guiding the discussion direction through questions, ensuring the discussion stays focused on teaching objectives and avoids excessive digression.

3. Post-class evaluation: Require students to independently or in groups conduct in-depth analysis of assigned cases and write reports, assessing their information processing, logical reasoning, solution formulation, and written expression abilities.

4.3 Accurate Evaluation and Continuous Improvement of Case Teaching Effectiveness

Scientific evaluation is key to ensuring teaching quality and achieving continuous optimization. Accurate assessment of student performance is an important means of improving teaching methods and enhancing teaching effectiveness.

4.3.1 Evaluation Implementation Process

Typically, student performance in academic education consists of final summative scores and formative assessment scores [7]. For professional education students, evaluation of teaching effectiveness can be extended to the post-work period, dividing evaluation into three stages: process assessment, summative assessment, and follow-up assessment, testing the reflection of teaching effectiveness in actual work throughout the entire process.

Process assessment: Observe students' enthusiasm, contribution, and depth of thinking in pre-class preparation, group discussions, and whole-class presentations (reflected through interaction, question quality, discussion records). Peer assessment and group observation can be combined to evaluate communication, collaboration, and leadership skills. Summative assessment: Assess knowledge mastery and application ability through case analysis reports, test questions, and defenses; assess practical ability through operational assessments and exercise performance; assess analytical, decision-making, innovative, communication, and expression skills through comprehensive observation and structured scales. Follow-up assessment: Establish a feedback mechanism for students' job performance. Collect data on students' satellite navigation support capabilities after assuming positions through their employers, compare with on-campus assessment results, and form a closed-loop basis for improvement.

4.3.2 Utilization of Evaluation Results

Based on evaluation results, real-time guidance can be provided to students: offer specific, constructive feedback to help students understand their strengths and weaknesses. It can also support teachers' course optimization and dynamic case database updates: ① Teaching reflection and improvement: Teachers reflect on the rationality of case selection, teaching design, guidance methods, and time allocation, optimizing case content and teaching methods. ② Dynamic case database update: Based on feedback and results, eliminate outdated or ineffective cases, add new cases, and revise existing cases.

5. Summary

Case teaching is a strategic teaching method deeply aligned with the inherent needs of satellite navigation professional education. By constructing realistic work scenarios, it integrates abstract technical principles, equipment operation, system management, etc., into specific problem-solving processes, effectively stimulating students' active learning, deep thinking, collaborative inquiry, and on-the-spot decision-making abilities. This study systematically constructs a satellite navigation professional education case teaching system covering the entire chain of "case database construction - teaching implementation - effectiveness evaluation." The aim is to systematically and qualitatively promote the application of case teaching in satellite navigation professional education, enhance teaching attractiveness, impact, and effectiveness, and compensate for the deficiencies of traditional teaching methods in cultivating students' job adaptability, complex problem-solving abilities, ad hoc decision-making skills, and innovative thinking. While imparting knowledge and skills, it shapes students' professional qualities, providing support for cultivating professional talent in the field of satellite navigation.

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References

- [1] Shen Qihua, Wang Xiaojie, Wang Liqiang, et al. Research on the Problems and Countermeasures of Post Education in Military Colleges[J]. Education and Teaching Forum, 2019(51):2. (in Chinese)
- [2] Lou Shengqiang, Tang Xiaomei, Li Zhengrong, et al. A Study on New-type High-quality Military Talent Cultivation Based on Beidou Practice[J]. Journal of Higher Education Research, 2020, 43(1):5. DOI:10.3969/j.issn.1672-8874.2020.01.007. (in Chinese)
- [3] Liu Xiaohui, Yu Meiting, Mou Weihua. Curriculum Group Construction of Military Vocational Education Based on Satellite Navigation [J]. Journal of Higher Education, 2022, 8(31):4. (in Chinese)
- [4] Wang Zhen, Xiao Zhicai, Zhang Wenguang, et al. Exploration and Practice of Professional Course Construction Model of Military Academy Post-education [J]. Education and Teaching Forum, 2021(15):113-116. (in Chinese)
- [5] Wang Jinxin, Li Aimin, Chen Chen. Application of Case Teaching in Science and Engineering Courses[J]. Western China Quality Education, 2024, 10(16):177-180. (in Chinese)
- [6] Yan Min, Lu Feng, Hu Chou. Research on Case-based Teaching Methods for In-service Cadre Professional Education[J]. Continuing Education, 2014(12):2. DOI:10.3969/j.issn.1006-9720.2014.12.023. (in Chinese)
- [7] Shi Yumin, Zhou Bin, Sun Weiqi. Research on Evaluation Index of Blended Teaching in Vocational Education of Military Academies [J]. China Educational Technology & Equipment, 2023(4):83-86. (in Chinese)