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Exploration and Practice of Ideological and Political Education in the Course "Introduction to Satellite Navigation Systems"

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Abstract: Ideological and political education within courses is a key development direction in the context of higher education under the framework of Socialism with Chinese Characteristics in the New Era. Compared to courses in the humanities and social sciences, the implementation of ideological and political education in science and engineering courses faces more challenges. By thoroughly exploring the ideological and political elements embedded in the course "Introduction to Satellite Navigation Systems," a teaching syllabus for ideological and political education was developed, along with the creation of a database of ideological and political elements related to satellite navigation and positioning. Specific implementation pathways were discussed, using examples such as "Principles of Global Navigation Satellite Systems (GNSS)," "Satellite Signal Propagation Errors," "Multipath Effects," "Differential Positioning Technology," and "International Development of the BeiDou System." Practice has shown that this method of integrating ideological and political education not only enhances students' professional knowledge but also fosters their patriotism and sense of social responsibility, achieving positive educational outcomes.

1. Introduction

Despite the strong emphasis placed on ideological and political education at the policy level, science and engineering courses-particularly those in highly technical fields-face more complex challenges in actual teaching practice[1]. Compared to humanities and social sciences, the content of science and engineering courses is often more specialized and technical, making it significantly more difficult to extract and integrate ideological and political education elements into these courses. "Introduction to Satellite Navigation Systems," as a professional course covering Global Navigation Satellite Systems (GNSS), positioning technologies, and their applications, features a complex knowledge system that spans from basic theory to engineering practice. How to effectively incorporate ideological and political education into this course has become a pressing issue.

In current research, studies on the ideological and political integration in courses related to

satellite navigation and positioning systems remain relatively scarce, with most focusing on improvements in teaching methods. For example, some research has explored the potential of integrating ideological and political education through case-based teaching methods[2,3]. However, these studies often limit their analysis to individual cases and lack systematic exploration and practice. At the same time, as satellite navigation and positioning technologies gain widespread global application, particularly against the backdrop of the accelerated internationalization of the BeiDou system, it becomes increasingly important to guide students through ideological and political education to foster patriotism, enhance their sense of social responsibility, and enable them to play a greater role in global competition. Therefore, systematically extracting ideological and political elements related to navigation and positioning and constructing a comprehensive ideological and political teaching system within the "Introduction to Satellite Navigation Systems" course holds significant importance for advancing ideological and political education in science and engineering courses.

This paper aims to analyze the characteristics and content of the "Introduction to Satellite Navigation Systems" course, exploring how to effectively integrate ideological and political elements into the course, and proposing specific implementation pathways for teaching. Through these explorations and practices, the hope is to provide valuable insights for the ideological and political development of science and engineering courses, thereby contributing to the advancement of higher education in the new era.

2. Current Status of the Course "Introduction to Satellite Navigation Systems"

This course is a core foundational course for undergraduates majoring in marine technology, designed to systematically introduce the fundamental principles, technical methods, and applications of Global Navigation Satellite Systems (GNSS). It aims to provide students with a solid theoretical foundation for further study and research in related fields[4]. Through this course, students will gain a comprehensive understanding of the background, basic functions, major application areas, and future development trends of navigation and positioning systems. They will master key concepts of GNSS, including signal transmission and processing, positioning algorithms, and error analysis, while improving experimental operation skills and proficiency with GNSS-related software. The course also focuses on developing students' abilities to identify and solve problems, particularly by strengthening their hands-on and technical application skills, laying a solid foundation for future work in related technical fields and research[5,6]. Furthermore, the course emphasizes fostering students' understanding and application of China's indigenous navigation systems, such as the BeiDou system, in a global context, thereby enhancing their patriotism and sense of social responsibility.

"Introduction to Satellite Navigation Systems" is an elective foundational course that plays a crucial role as the supporting technology for global positioning techniques. The course has found wide application in various fields, both domestically and internationally, particularly in transportation, precision agriculture, national defense, and public safety[7,8]. The course content covers the basic concepts and components of GNSS systems, satellite orbit theory, satellite signal propagation and its associated errors, multipath effects, differential positioning techniques, precise point positioning, and integrated applications of satellite navigation and location-based services[9-11]. It provides an in-depth introduction to the latest research developments in modern navigation and positioning technologies, as well as practical application cases. This course is critical for students to grasp the fundamental knowledge of navigation and positioning technologies, thereby enabling them to conduct advanced application research and technological development.

The textbook used for this course is "Introduction to Satellite Navigation Systems", edited by

Zhang Xiaohong and others. It consists of nine chapters, covering an overview of navigation systems, fundamental GNSS theories, satellite signal processing, positioning algorithms and error analysis, GNSS application technologies, the BeiDou navigation system, satellite orbit and navigation signal simulation, cutting-edge navigation technologies, and future applications. Due to the heavy involvement of mathematical models, physical theories, and technical details, students generally find the theoretical aspects of the course challenging, particularly when mastering complex positioning algorithms and error-handling methods.

The course is rich in content, highly technical, and widely applicable. How to subtly integrate ideological and political elements into the teaching process, while stimulating students' interest, improving their professional skills and practical abilities, and achieving educational goals through ideological and political education, has become a key issue in the current course delivery.

3. Teaching Design for Ideological and Political Education in the Course

The outline clearly states that science and engineering courses should integrate Marxist principles, viewpoints, and methodologies during the teaching process to cultivate students' scientific spirit and enhance their ability to recognize, analyze, and solve problems correctly. Specifically, engineering courses, particularly those closely related to engineering technology, emphasize the importance of reinforcing engineering ethics education, cultivating the spirit of precision and excellence, and inspiring a sense of patriotism and responsibility in serving the nation's technological needs.

In accordance with the relevant requirements of the outline and opinions, and aligning with the talent cultivation goals and teaching syllabus of the marine technology major, a systematic teaching design for ideological and political education was developed for the “Introduction to Satellite Navigation Systems” course. The course’s professional characteristics and practical teaching requirements were fully considered, while the teaching team, led by the author, drew from personal research projects and teaching experience. A detailed teaching syllabus for ideological and political education was formulated, and a comprehensive database of ideological and political elements was established.

In the teaching design, the development history of GNSS technology and the independent innovation of China's BeiDou system were used as entry points to guide students in understanding the significance of technological innovation for national security and social development. This approach aimed to inspire their sense of patriotism and responsibility. Through the introduction of international case studies involving the BeiDou system, students were encouraged to develop a global perspective and a sense of mission in advancing science and technology for the country. Additionally, when explaining complex theories such as GNSS signal processing and error analysis, emphasis was placed on cultivating scientific thinking and problem-solving abilities. Discussions on engineering ethics were also introduced to reinforce students' sense of professional ethics and social responsibility in real-world engineering applications.

In practice, case-based teaching methods were emphasized to integrate theory with real-world applications. For instance, by analyzing the practical applications of the BeiDou system in emergency rescue, precision agriculture, and transportation, students not only deepened their understanding of theoretical knowledge but also developed their engineering practice skills and teamwork spirit. Students were also encouraged to participate in related research projects and experimental designs to enhance their hands-on abilities and innovative thinking. This approach fostered a sense of responsibility and mission to explore unknown fields and pursue scientific excellence.

This course design for ideological and political education not only achieves the seamless

integration of course content with ideological education but also effectively enhances students' professional competence and social responsibility, laying a solid ideological foundation for their future development in the field of navigation and positioning technologies.

4. Practice of Ideological and Political Education in the Course

Building upon the course's ideological and political education design, practical implementation was carried out in the fall semester of 2021, targeting undergraduates majoring in marine technology (class of 2022). The approach adopted was to subtly incorporate ideological and political elements while teaching professional knowledge. The main practices of this ideological and political education in the course are as follows:

4.1. GNSS Signal Propagation Errors

GNSS signal propagation errors are a critical topic in the navigation and positioning systems course. These errors, caused by complex physical phenomena such as the ionosphere, troposphere, and ground reflection, directly affect positioning accuracy. To help students understand this topic and incorporate ideological and political education:

First, the analogy of “light refraction in water” was used to explain signal propagation errors. An experiment demonstrating light bending when passing through different media was shown, encouraging students to compare this with the process of GNSS signal error generation in the atmosphere. This analogy helped students visually grasp the physical mechanisms behind signal propagation errors.

Next, the course introduced the technological innovations of the BeiDou system in overcoming signal propagation errors, particularly through the use of multi-frequency signals and differential techniques to improve positioning accuracy. This not only aided students in understanding the practical application of advanced technologies but also instilled a sense of pride in China's independent innovation capabilities. To further integrate ideological and political elements, the instructor referenced President speeches on the importance of technological self-reliance, highlighting the crucial role of technology in national security and development.

In this way, students not only mastered the technical knowledge but also developed a deeper sense of social responsibility and mission. This teaching design enabled students to understand complex concepts while simultaneously cultivating a strong sense of patriotism, achieving an organic combination of course instruction and ideological education.

4.2. Multipath Effect

The multipath effect is a significant phenomenon in GNSS signal propagation. When signals encounter obstacles, reflection and refraction occur, causing the receiver to receive signals from multiple paths, which in turn affects positioning accuracy. This topic involves complex physical phenomena, and students often face challenges in understanding it. To address this, the course design incorporated analogies and real-world examples to introduce ideological and political education, helping students better grasp this concept.

First, when explaining the multipath effect, the instructor used the analogy of “mirror reflection.” By demonstrating the process of light reflecting off a mirror, students were guided to understand how signals reflect off different surfaces, resulting in multiple signal paths that affect reception. This intuitive analogy helped students understand the essence of the multipath effect, laying a solid foundation for further learning.

Next, the course introduced practical examples of how the BeiDou system overcomes the

multipath effect in complex urban environments. The instructor explained how BeiDou uses advanced algorithms and multipath suppression techniques to improve positioning accuracy. The application of these technologies in areas such as traffic management and emergency rescue was emphasized. Through these real-world examples, students not only learned the technical solutions to the multipath effect but also gained an appreciation for China's leading position in global navigation technology, strengthening their national pride.

To further deepen the ideological and political education, the instructor discussed the importance of technological advancements for societal development, particularly in the context of global competition. By analyzing the competition and cooperation between the BeiDou system and other international navigation systems, students were encouraged to develop a global perspective and were inspired with a sense of responsibility to contribute to the nation's technological progress.

Finally, the instructor organized group discussions where students explored the challenges of the multipath effect in practical applications and proposed potential solutions. During these interactive sessions, students actively participated and offered many innovative ideas, demonstrating their deep understanding of the subject and their concern for the country's technological development. Through this interactive teaching approach, students' patriotism and professional competence were simultaneously enhanced.

4.3. Differential Positioning Technology

Differential positioning technology is a key technique for improving the accuracy of GNSS positioning by using reference stations to eliminate signal propagation errors, thus achieving high-precision positioning. This technology holds a significant position in the navigation and positioning systems course, requiring students to grasp complex mathematical models and practical application methods. To enhance students' understanding of this topic while incorporating ideological and political education, the course design employed various teaching methods.

First, to help students better comprehend differential positioning technology, the instructor introduced the concept of “teamwork” as a starting point. The relationship between the reference station and the mobile receiver was likened to that of partners in a team, emphasizing that cooperation and coordination are essential in engineering practices. This analogy not only clarified the basic principles of differential positioning but also underscored the importance of collaboration in engineering.

Next, the course provided a detailed explanation of the practical applications of differential positioning technology in the BeiDou system, especially its critical role in emergency rescue and disaster monitoring. Concrete examples were presented, such as how the BeiDou system used differential positioning technology to provide precise location information during the Wenchuan earthquake rescue efforts. Through these examples, students were guided to recognize the profound societal impact of technology. This approach not only deepened their understanding of differential positioning but also fostered a sense of social responsibility and a willingness to serve.

In addition, the instructor connected the discussion to current affairs by highlighting the role of the BeiDou system in the “Belt and Road” initiative, particularly in the infrastructure development of countries along the route. This discussion helped students realize the crucial role of Chinese technology in global development, reinforcing their patriotism and sense of mission.

Finally, to solidify students' understanding of differential positioning technology, the instructor organized a classroom discussion on the challenges and solutions associated with applying differential positioning in various scenarios. Through the discussions, students offered creative insights, demonstrating their deep reflection on technical issues and their awareness of social responsibility. This interactive teaching approach not only enabled students to master complex

technical knowledge but also subtly strengthened their sense of social responsibility and their commitment to contributing to the nation's technological advancements.

4.4. International Development of the BeiDou System

The international development of the BeiDou system not only showcases China’s capability for independent technological innovation but also signifies the nation's pivotal role in the global navigation field. As a key component of the navigation and positioning systems course, this topic extends beyond technical learning and serves as a crucial entry point for ideological and political education, effectively enhancing students' national pride and global perspective.

First, while discussing the international development of the BeiDou system, the instructor presented its progression from regional service to global coverage, illustrating the rapid rise of China’s technological power and its increasing global influence. By comparing the strengths and weaknesses of the BeiDou system with other Global Navigation Satellite Systems (GNSS) such as GPS, GLONASS, and Galileo, students gained a clearer understanding of the competitive edge and unique advantages of the BeiDou system in the global market. This comparison not only helped students grasp technical details but also reinforced their sense of pride in China’s achievements in independent innovation.

Next, the instructor deepened students’ understanding of the global impact of the BeiDou system through a series of real-world international application cases. For instance, the successful application of the BeiDou system in infrastructure development, precision agriculture, and disaster early warning in countries along the Belt and Road Initiative (BRI) demonstrated how it elevated local technological capabilities while promoting cooperation and mutual trust between China and these nations. These examples not only highlighted the system’s success in the global market but also made students recognize the vital role of technology in fostering global cooperation and peaceful development, thereby inspiring their patriotism and sense of global responsibility.

Additionally, the instructor linked the discussion to President concept of building a “community with a shared future for mankind,” focusing on how the BeiDou system serves the welfare of humanity in a globalized context. Through this discussion, students were encouraged to consider China’s role as a responsible major power in global technological development and international cooperation. This approach instilled in them a sense of duty to serve the country and contribute to the world.

Finally, the instructor organized a group discussion on the challenges and opportunities faced by the international development of the BeiDou system, as well as how China can address global competition through technological innovation. Students actively participated, presenting unique insights on technological advancement and international collaboration, reflecting their global outlook and strategic thinking skills. This interactive approach simultaneously enhanced both their professional knowledge and ideological awareness.

Teaching the international development of the BeiDou system not only equipped students with technical knowledge but also, through effective ideological and political education, fostered their national pride, global responsibility, and a sense of mission to contribute to the country’s technological progress. This practice fully achieved the dual goals of course instruction and ideological education.

5. Conclusion

This paper, using the “Introduction to Satellite Navigation Systems” course for marine technology majors as an example, introduces the current status of the course and develops an ideological and political education syllabus, while building a database of ideological and political

elements. By exploring four key knowledge points—GNSS signal propagation errors, multipath effects, differential positioning technology, and the international development of the BeiDou system—the paper analyzes how to seamlessly integrate ideological and political elements into the course. During the semester-long teaching practice, the educational outcomes of integrating ideological and political education were significantly realized, meeting the anticipated teaching goals.

In future teaching, the team will continue to explore and identify ideological and political material related to navigation and positioning, further enriching the ideological element database. The aim is to continually deepen the integration of ideological and political education with professional teaching, thereby improving the quality of talent cultivation and contributing to the development of high-quality professionals who possess patriotism, social responsibility, and innovative capabilities.

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