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Exploration of the Teaching Reform and Practice of Single-Chip Microcomputer Course for Aviation Majors under the Empowerment of Low-Altitude Economy

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Abstract: With the emergence of the concept of low-altitude economy and the continuous upgrading of avionics technology, cultivating aerospace professionals with single-chip microcomputer (SCM) knowledge and practical abilities has become an important reform direction for undergraduate education. From the perspective of course application, this paper explores the necessity of introducing SCM courses and reforming teaching methods for aerospace majors at the undergraduate level, and puts forward reform suggestions in teaching content, teaching methods, practical links, and evaluation systems. It aims to build a curriculum system that not only conforms to the characteristics of aerospace majors but also strengthens students' SCM engineering application literacy and cultivates applied compound talents for the aviation industry related to the low-altitude economy.

Keywords: Aerospace majors; Single-Chip Microcomputer (SCM); Undergraduate education; Teaching reform

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1. Introduction

On January 31, 2024, at the 11th collective study session of the Political Bureau of the CPC Central Committee, the General Secretary stressed that we should accelerate the development of new quality productivity and solidly promote high-quality development. As an important representative of the new productive forces, the low-altitude economy is a comprehensive economic form that radiates and drives the integrated development of related fields around the manned, cargo, and various operation requirements of low-altitude flight scenarios with various types of manned and unmanned aircraft as carriers [1–3]. As the core and basic component of an avionics system, Single-Chip Microcomputer (SCM) is more and more widely used in the field of aviation. From aircraft attitude control, sensor data acquisition, and autopilot assistance to the path planning and execution of low-altitude logistics UAVs, signal processing of emergency rescue equipment, and control of intelligent transportation and aviation monitoring terminals, all are inseparable from the support of SCM technology.

Colleges and universities undertake the core mission of cultivating professional talent for the country. Under the dual background of the vigorous development of the low-altitude economy and the intelligent upgrading of aviation technology, it is particularly critical to cultivate aerospace professionals proficient in SCM technology, improve talent training quality, and supply high-quality scientific research and applied talents for the upstream and downstream industries of the low-altitude economy. However, at the current undergraduate stage, the teaching mode of the SCM course for aerospace majors is generally "theory-oriented, practice-deficient, and disconnected from aviation scenarios," which is difficult to adapt to the engineering application characteristics of SCM technology and the actual needs of the aviation industry [4–6]. Therefore, it is imperative to carry out systematic teaching reform of the SCM course for aerospace majors.

2. Necessity of integrating SCM into aerospace majors

In recent years, the maturity and upgrading of SCM technology have continued to drive the development of aviation equipment toward miniaturization, intelligence, and low-cost. SCM has the characteristics of small size, low power consumption, high reliability, and strong programmability, and can perfectly meet the lightweight design requirements of aviation equipment (especially UAV and light aircraft). Through its logic control and data processing capabilities, SCM enables the stable adjustment of aircraft attitude, the fusion of multi-sensor data (e.g., the integration of GPS, gyroscope, and accelerometer data), and significantly enhances the autonomous operational capabilities of aircraft. In the field of low-altitude logistics, as the core of the UAV flight control system, SCM can accurately execute path planning instructions, load state monitoring, and emergency braking control. In the military field, the widespread application of various small intelligent aircraft in the Russia-Ukraine War highlights the core value of SCM in low-cost and high-reliability combat equipment. The reconnaissance UAV, patrol missile, and other equipment supported by SCM have changed the traditional battlefield form with the advantages of rapid response and precise control. Therefore, it is key for aerospace majors to master SCM technology to meet the needs of industry development and enhance employment competitiveness.

The integration of SCM technology into the teaching of aerospace majors can not only cultivate students' engineering practice ability and innovative thinking, improve their comprehensive quality, but also promote the cross integration of electronic technology, automation, aviation engineering and other disciplines, which is in line with the social responsibility of colleges and universities to serve the industry and promote the development of science and technology. At present, many colleges and universities in China have taken the lead in promoting relevant teaching exploration. It can be seen that it can be seen that introducing the SCM course and deepening teaching reforms in aerospace majors have sufficient support from industry demand and teaching practice foundations.

3. Current problems in SCM teaching

3.1. Teaching content

Although the SCM technology has been relatively mature, new models, functions, and application scenarios are still being continuously updated. For example, the multi-core architecture, IOT interface integration, low-power optimization, and other new technologies of the STM32 Series High-Performance SCM are difficult to incorporate into the existing curriculum system in time, resulting in a lag between the teaching content and the actual application of the industry, and the disconnection between the students' knowledge and engineering practice.

SCM is a typical interdisciplinary technology, involving electronic technology, digital circuits, analog circuits, C language programming, microcomputer principles, and other prerequisite courses. Although this interdisciplinary characteristic helps to cultivate students' comprehensive ability, it also greatly increases the learning burden. Some students feel intimidated by the SCM course due to weak foundations in analog and digital electronics or insufficient programming skills. At the same time, different students' learning habits and knowledge reserves are quite different. The unified theoretical teaching mode leads to uneven learning effects, and it is difficult to fully mobilize students' learning enthusiasm.

The core value of the SCM course lies in engineering application, but in the current teaching of aerospace specialty in most colleges and universities, the proportion of theoretical class hours of SCM is too high, and the practice class hours are seriously insufficient. At the same time, the teaching content mostly focuses on pure theoretical knowledge, such as the internal structure of SCM and the instruction system, and lacks practical training combined with aviation scenes. It is difficult for students to understand the practical application of theoretical knowledge in aircraft control, and they lack practical experience in hardware welding, programming, debugging, and troubleshooting. In addition, pure theoretical content is tedious, which further reduces students' interest in learning, leaving them helpless when confronting practical engineering problems in the aviation field.

3.2. Teaching resources

SCM teaching is highly dependent on hardware resources, while ordinary colleges and universities are generally faced with the dilemma of insufficient teaching resources. High-performance SCM development boards (e.g., aviation-specific anti-interference development boards), multi-type sensor modules (GPS, gyroscopes, barometers, etc.), simulators, oscilloscopes, and logic analyzers are expensive and require regular updates and maintenance. Most colleges and universities struggle to equip sufficient equipment to meet students' individual operational needs. Some colleges and universities still use the old model 51 SCM development board, which is out of touch with the industry's mainstream high-performance microcontrollers such as STM32 and PIC. At the same time, due to the lack of an aviation scene-based training platform, practice teaching can only stay at the basic level of "lighting LED, simple serial communication," which cannot simulate the complex application environment in the aviation field, and it is difficult to exercise students' engineering practice ability.

In addition, SCM practical teaching needs supporting software resources and technical support, while ordinary colleges and universities often lack professional training guidance materials and industry-level technical case library, so it is difficult for students to obtain targeted guidance in the process of practice, and problems cannot be effectively resolved when they encounter hardware failures or program bugs, which seriously affects the teaching effect.

3.3. Assessment methods

At present, the assessment of the SCM course still relies on the final examination, and the assessment format is mostly a written exam, which has obvious drawbacks. The core ability of SCM is engineering application, while the written test focuses on theoretical memory, which cannot reflect students' practical abilities such as hardware selection, programming, debugging, and troubleshooting, and project development. The core goal of the SCM course for aerospace majors is to "serve aerospace applications," but the written test content is difficult to relate to the actual application needs of aviation scenarios, which leads to students excessively focusing on theoretical memorization and neglecting the training of practical capabilities, resulting in the phenomenon of "putting the cart before the horse." At the same time, the single written examination brings great test pressure to students, leading to students' anxiety before the examination, a lack of in-depth thinking and flexible use of knowledge, which is not conducive to students' all-round development.

4. Teaching reform measures

4.1. Teaching content optimization

Guided by the characteristics of aerospace majors, the teaching content closely related to aerospace applications is screened. STM32 Series SCM, which is the mainstream in the industry, is selected as the core to explain the core application modules of SCM in the aviation field, such as I/O port expansion, interrupt systems for aircraft attitude control, data acquisition of aviation-grade sensors (ADC analog-to-digital conversion), UAV communication interfaces (UART, I2C, SPI), and low-power design (to meet aircraft endurance requirements), etc., so as to narrow the scope of teaching, clarify the teaching objectives, and reduce the difficulty of students' learning.

Properly reduce the requirements for explaining the complex circuit structure and the underlying principle of the instruction system inside the single-chip microcomputer, and focus on the combination of theory and practice. For example, when explaining the interrupt system, it is necessary to carry out the interrupt programming practice of emergency data acquisition of aviation sensors simultaneously. When explaining the timer, programming training is carried out in combination with the timing sampling case of UAV flight attitude. At the same time, the C language is used as the core programming tool to explain the use of the KEIL development environment and stm32cubemx configuration tool, so that students can master the basic programming and development process in the theoretical learning stage.

Introduce real projects to meet the needs of the industry. The practice course takes the aviation scenario project as the core and introduces open and practical project resources. Each project is allocated 8–10 class hours, adopting a model of independent exploration, teacher guidance, and analysis. First, let the students complete the project design, hardware welding, programming, and debugging independently in groups, and then the teachers analyze the key difficulties in the projects to align with the latest industry technology development trends.

4.2. Assessment system reform

Establish a project-oriented comprehensive assessment system, abandon the single written examination mode, and take the aviation scene SCM project as the core for assessment. Students are required to complete a whole project independently and submit hardware objects, source code, debugging report, and project demonstration video. The assessment dimensions include function realization (40%), stability and anti-interference (20%), code quality (20%), innovation (10%), and report standardization (10%).

Add process assessment, including classroom practice performance (10%), project progress and phased results (10%), learning attitude and cooperation ability (5%), after-school homework (5%), and comprehensively evaluate students' learning process and comprehensive ability.

4.3. Feedback mechanism improvement

Establish a normalized teaching feedback mechanism to ensure the continuous optimization of teaching reform. Anonymous questionnaires were used to regularly collect students' opinions and suggestions on teaching content, teaching methods, practice resources, and assessment methods. Combined with the industry technology update trends, timely adjust the teaching content, optimize the practice project, improve the resource allocation, form a closed-loop mechanism of feedback, improvement, and promotion, and continuously improve the teaching quality.

5. Conclusion

Under the background of the rapid development of the low-altitude economy and the accelerated cultivation of new quality productivity, as the core technology of the avionics system, the curriculum reform of SCM is a key measure for aerospace majors to adapt to the needs of the industry and improve the quality of talent cultivation. Taking aerospace majors as an example, this paper analyzes the necessity and current problems of the SCM course, and constructs a curriculum system that meets the characteristics of the aerospace major and engineering application needs by optimizing teaching content, innovating teaching methods, strengthening practice links, and reforming the assessment system. It aims to cultivate interdisciplinary talents with the application ability of SCM technology and the adaptability of the aviation industry, improve students' learning enthusiasm and initiative, and provide talent support for the high-quality development of the aviation industry related to the low-altitude economy.

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Disclosure statement

The author declares no conflict of interest.

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