Research and Practice of Teaching Reform in "C++ Programming and Algorithm Implementation" under the New Engineering Education Background

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Abstract: In the context of the new engineering construction, the teaching of "C++ Programming and Algorithm Implementation" for robotics engineering majors faces challenges: the teaching content needs to closely align with professional requirements such as real-time control of robots, operation of low-level hardware interfaces, and efficient algorithm implementation. There are issues such as weak teaching foundation, disconnected practice, and lack of innovation. To address these three major pain points, this course teaching reform is based on the core competency requirements of robotics engineering majors for C++, proposing an "understanding-refinement-leap" progressive teaching model. It conducts open practical teaching reforms in multiple dimensions, breaks down barriers between industry and education through teaching method reforms that integrate industry and education, and supports innovative talent cultivation through project support. It aims to cultivate applied advanced specialized talents with practical abilities and innovative spirit, who are engaged in design and manufacturing, technology development, scientific research, engineering applications, and other work in robotics and related fields, and can solve complex engineering problems.

***Keywords*:** new engineering, robot engineering, rogramming language, teaching reform

1. Introduction

The C++programming language occupies a core position in the field of high-performance computing. The International C++Standards Committee (ISO/IEC JTC1/SC22/WG21) continues to promote standard updates for the C++language, introducing modern programming features in versions such as C++11, C++14, C++17, C++20, and the upcoming C++23. At the same time, in the context of the country's promotion of independent and controllable information technology, C++, as a system level programming language, plays a key role in the research and development of basic software and hardware such as domestic operating systems, databases, and chip design. Domestic higher education institutions have strengthened the teaching and research of C++, not only focusing on the language itself, but also attaching importance to teaching modern software engineering practices, system programming ideas, and performance optimization techniques through C++programming and algorithm implementation courses [1-3]. Due to the complexity and wide range of applications of the C++programming language, high standards are required for software engineers to possess both deep programming language and algorithm implementation skills, as well as the ability to understand specific domain knowledge (such as intelligent robots). This poses a challenge for team building and project advancement in enterprises, and the key to breakthrough lies in the cultivation and reserve of innovative talents.

In order to meet the needs of the new round of technological revolution and industrial transformation, the new engineering background emphasizes the reform and innovation of traditional engineering education, forming new educational concepts, disciplinary systems, and talent training models [4,5]. In this context, the field of robotics is no longer limited to the traditional imparting of knowledge from single disciplines such as mechanical engineering and electronic engineering. Instead, it places greater emphasis on deep interdisciplinary integration, organically combining knowledge from multiple fields such as computer science, artificial intelligence, automation control, and materials science, with the aim of cultivating composite talents who can design, develop, apply, and maintain intelligent robots [6,7]. Therefore, the cultivation of professional talents integrating computer science and robotics engineering technology under the background of new engineering disciplines is facing unprecedented challenges and opportunities.

As the saying goes, 'To do a good job, one must first sharpen one's tools.' The rapid development of computer storage and computing power provides strong support for the advancement of engineering technology. C++, as an efficient programming language, plays a core role in various fields such as controlling mechanical operation, software development, system design, and game development. Especially in today's rapidly developing robotics technology, C++has become one of the key tools driving the practical application of algorithms and programming techniques [8,9]. C++maintains the encapsulation and powerful functionality of object-oriented languages in programming, enabling direct conversion into machine code with fast execution speed. It allows developers to organize code through classes and objects, and has rich library support, such as ROS (Robot Operating System), providing a powerful toolkit for robot research and becoming the preferred tool for robot system control and analysis [10,11].

The course of "C++Programming and Algorithm Implementation" aims to cultivate applied senior specialized talents who not only master the basic theory and professional knowledge of robotics, but also have strong practical abilities and innovative consciousness through close integration with the field of robotics. This teaching model not only enhances students' programming and problem-solving abilities, but also promotes the learning of interdisciplinary knowledge. At the same time, by integrating ideological and political education, it enhances students' sense of social responsibility and patriotism, providing a solid talent guarantee for solving complex engineering problems.

2. Current Problems in Teaching C++Programming and Algorithm Implementation Course

The 14th Five Year Plan points out that data is the key element, and the deep integration of digital technology and the real economy is the main line. It strengthens the construction of digital infrastructure, improves the governance system of the digital economy, and synergistically promotes digital industrialization and industrial digitization. The development of these fields often requires the support of programming languages. Our city has over 1000 large-scale software information enterprises with 100000 employees. The advantages of basic software are gradually emerging, industrial software is developing rapidly, and industrial resources are accelerating the demand for talent gathering. Therefore, the course of "C++Programming and Algorithm Implementation" has received high attention from various majors in domestic and foreign universities. Actively offering and promoting undergraduate teaching of "C++Programming and Algorithm Implementation" not only aims to cultivate a large number of excellent talents for data analysis in China, but also to seize the high ground of talent cultivation and college student employment.

Through teaching practice in recent years, although certain achievements have been made, the teaching method of the course "C++Programming and Algorithm Implementation" still remains at the level of scattered sentence based teaching, neglecting the cultivation of students' ability to systematically solve practical problems in robot engineering using the C++language; In addition, the outdated one-way teaching and learning approach of "teacher lecturing student listening" is difficult to stimulate students' classroom interest, causing them to "turn pale when talking about learning". Based on the above issues, in the field of C++programming and algorithm implementation, the phenomenon of difficult employment for students and difficult employment for enterprises is still significant. The specific reason is shown in Figure 1:

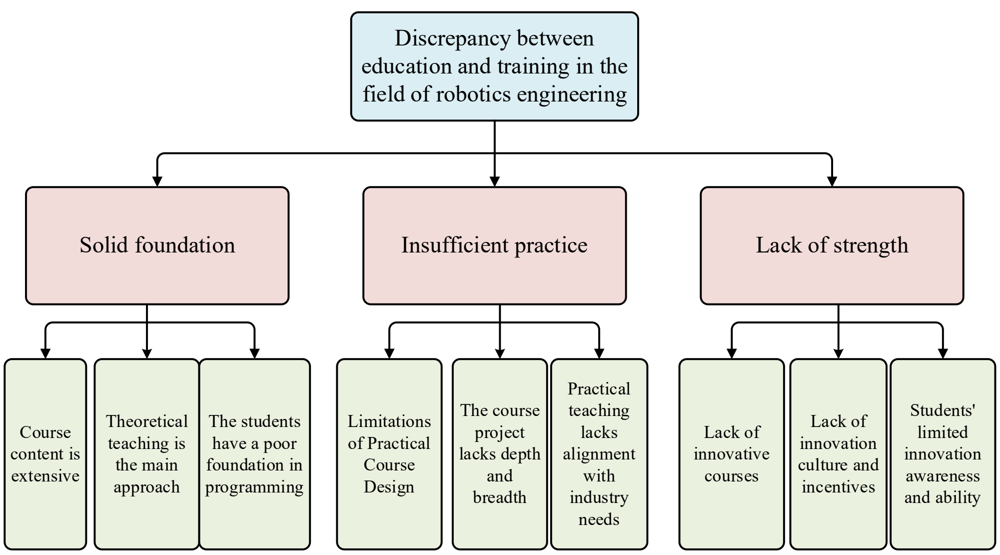

Figure 1. The problems faced by the course of C++ programming and algorithm implementation

2.1 Lack of solid foundation.

weak basic knowledge, about 20% of students believe that their understanding of theoretical knowledge is not deep, and there are many difficulties in practical application.

2.2 Shortcomings in practice.

There is a mismatch between theory and practice, with theoretical knowledge accounting for up to 70%. About 85% of companies believe that the practical operational skills of newly hired employees cannot immediately meet job requirements.

2.3 Lack of creativity.

Students have poor innovation ability, with less than 30% of them participating in extracurricular innovation projects or competitions, and their ability to solve practical robot engineering problems needs to be improved.

3. Curriculum Construction and Teaching Reform under the Background of "New Engineering"

In the context of new engineering disciplines, the innovative teaching mode reform of "C++Programming and Algorithm Implementation" follows the advanced thinking of "enlightenment refining leap". Through this cultivation mode, not only does it build a seamless connection channel for students from campus to workplace, but it also promotes regional robot industry technology innovation and ecological upgrading with talent support, achieving deep integration of education chain, talent chain and industry chain, and providing sustainable intellectual support for high-quality development of regional economy and society. As shown in Figure 2, this cultivation mode is promoted in three stages:

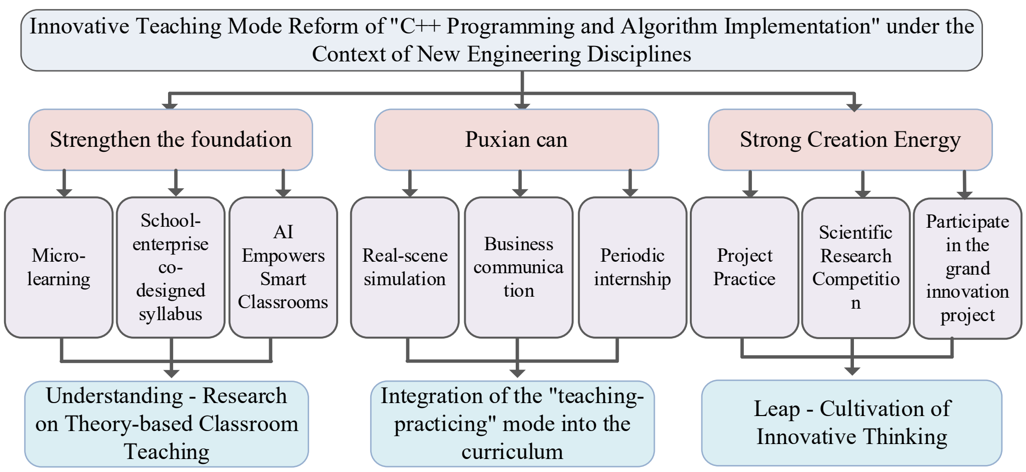

Figure 2. C++ programming and algorithm implementation "enlightenment refining leap "construction architecture

3.1 Understand and solidify the foundation.

The key to constructing and implementing a teaching system lies in forming a closed-loop ecosystem of "knowledge accumulation industry education integration intelligent diagnosis". Anchoring cognitive granularity with micro learning strategies as the foundation: By finely breaking down the core concepts of the course to form a "fragmented knowledge push" sequence, and designing multi gradient "micro project practice" tasks, students can achieve the transformation of knowledge from reception to application in a short period of time, solving the problem of theoretical and practical disconnection in traditional teaching. Leveraging school enterprise cooperation to achieve dynamic calibration of education direction: relying on systematic "enterprise demand research and analysis", deeply connecting with the technological evolution and talent capacity gap in fields such as intelligent hardware development and industrial robot integration, transforming industry standards into executable "teaching syllabus formulation and dynamic adjustment" mechanisms, ensuring that course content (such as embedded real-time system development and ROS2 framework application) always resonates with the forefront of the industry. Ultimately, the "last mile" of teaching optimization will be bridged through AI empowerment: an "intelligent teaching assistance system" will be introduced to provide personalized learning paths and resource adaptation for students, and based on the "intelligent analysis and feedback of classroom teaching" technology, real-time behavioral data of practical links (such as code debugging trajectories and algorithm design bottlenecks) will be captured, accurately generating learning heat maps and weak point training plans, forming an enhanced loop of "teaching diagnosis reinforcement". The three are interrelated: micro learning solidifies the knowledge base, school enterprise linkage anchors the ability coordinates, and AI engine drives precise teaching - together forming a self iterative teaching foundation project, enabling professional education to truly achieve the deep goals of rooted in industry needs, responding to technological changes, and empowering individual growth, laying a solid lifeline for cultivating new engineering talents with both solid foundation and innovative literacy.

3.2 Refining and replenishing practical abilities.

Practical teaching mode, based on the concept of new engineering, integrates enterprise demand cognition into C++courses and encourages students to actively participate. C++practical teaching constructs a three-dimensional training system through real-life simulations, enterprise exchanges, and phased internships, comprehensively enhancing students' engineering practice and professional competence. In real-life simulations, the operation of virtual project teams is a crucial step. Students form a team to develop an "online management system", playing different roles and completing the entire process from requirement research to code implementation, following development standards. At the same time, simulating project settings with time, environment, and resource constraints cultivates students' time management and code optimization abilities. Troubleshooting and emergency response simulation are also indispensable. By setting up network interruptions and other faults for students to debug, as well as simulating scenarios such as demand changes, students' problem-solving and adaptability abilities can be enhanced. Open up students' industry perspectives through corporate communication. Organize students to visit software, gaming, and other enterprises to understand the application of C++in practical projects, such as game engine development. Enterprise technicians will introduce the technology stack and industry trends. Invite enterprise experts to give lectures, share experiences in multi-threaded programming, and interact with students and experts to obtain career advice. The practice of school enterprise cooperation projects allows students to participate in actual enterprise projects, such as developing data analysis tools and understanding development standards under the guidance of enterprise mentors. Case studies analyze successful and failed cases to enable students to learn architecture design and avoid errors. The phased internship adopts a progressive training mode. During the basic internship stage, students complete basic tasks such as writing data encryption functions in junior positions and gain an understanding of enterprise processes. During the advanced internship stage, students independently undertake the development of game prop systems and other modules, participate in large-scale projects, and enhance their comprehensive abilities. After the internship, students summarize and reflect on their achievements, and the company provides feedback on their performance to the school. Based on this, the school improves teaching, such as strengthening the teaching of template programming and other content, enhancing students' employment competitiveness, and helping students comprehensively improve their knowledge mastery and professional abilities.

3.3 Leap - Strong Creativity.

Innovative thinking cultivation, flexible integration of C++into practical applications in the field of robotics, and deepening the training objectives of robotics engineering. In the practice and innovation of the robotics field, C++plays a key role as a core technology, demonstrating its strong application value from project practice to scientific research competitions, and even to large-scale innovation projects. The application of core technologies in practical robot projects lies in the fact that C++can implement motion planning algorithms, allowing robots to plan optimal paths in complex environments. At the same time, using C++to develop robot perception system drivers, real-time collection, preprocessing, and fusion of sensor data such as cameras can be carried out to construct accurate environmental models. Students use C++as a tool to develop a deep learning based autonomous decision-making system in a competition project that combines artificial intelligence and robots. They implement deep reinforcement learning algorithms to enable robots to autonomously learn and optimize decision-making strategies. In the college innovation and entrepreneurship training program, students incubate independent innovation projects using C++as the core technology. Carry out a project-based open teaching mode, encourage students to learn around robot engineering software development projects, expose them to cutting-edge technologies and practical application scenarios, guide students to participate in the process of requirement analysis, scheme design, implementation, and debugging of the project through analysis and solution of practical problems in robot engineering, fully experience the lifecycle of robot engineering software development, cultivate students' ability to apply professional knowledge and skills, as well as teamwork ability. Collaborative construction of open teaching between teachers and students, carrying out a series of practical technology activities, and comprehensively enhancing students' innovation ability.

4. Application Practice Achievements

4.1 Consolidate and solidify basic theories.

By optimizing the course content and teaching methods, the teaching effectiveness of the course "C++Programming and Algorithm Implementation" has been enhanced. Data shows that the average score of students' overall evaluation has increased from 78.34 to 83.35, and the pass rate has increased from 98% to 100%. The highest score has increased from 92 to 97, the lowest score has increased from 52 to 60, the excellence rate has increased from 5% to 28%, and the standard deviation has increased from 8.22 to 8.41. Over 95% of students demonstrated a profound understanding of core concepts and basic theories in their final exams. This indicates that students' basic theoretical knowledge has been effectively consolidated and deepened.

4.2 Improving the ability to solve engineering problems.

In the teaching design of the C++course, the content of practical hours has been adjusted by selecting practical cases closely related to robotics technology as teaching materials, and introducing multiple robotics engineering projects as course assignments. By participating in such projects, students can face challenges in the real world. Through practice, not only have programming skills been honed, but problem-solving skills, innovative thinking, and teamwork spirit have also been developed. Meanwhile, by discussing the application of these technologies in disaster relief, medical assistance, and other fields, students can also deeply appreciate the social value of technology

4.3 Enterprise visits enhance employment skills

In depth research on enterprise programming analysis platforms to enhance students' employability: Led students to visit industry-leading high-end robot equipment companies such as Chenxing (Tianjin) Automation Equipment Co., Ltd. and Zhejiang Pumai Technology Co., Ltd., visited enterprise data analysis platforms, human-computer interaction interfaces, and C++programming control systems, significantly improving students' mastery of the knowledge required by enterprises; Actively held symposiums between schools and enterprises, allowing students to understand the needs of enterprises and significantly improving their employment skills.

4.4 The application scope of course innovation achievements is wide

Solve practical cases of enterprise engineering projects. The course team and the enterprise jointly designed and developed an "intelligent detection system", which combines machine vision technology and mobile robot technology, supports two modes of fixed route movement and Bluetooth remote control, and can quickly scan and analyze paint surfaces. At the same time, based on image preprocessing technology and classification and recognition algorithms based on deep learning models, efficient detection of multiple defects under low light conditions is achieved through data analysis and model training. This project is based on C++assembly language to implement automatic control of intelligent cars and robotic arms, using the project as a case study to promote students' mastery of full process solutions and programming ideas for engineering problems, and to develop system level and project level programming abilities.

5. Conclusion

This study focuses on the core pain points of the course "C++Programming and Algorithm Implementation" in the field of robotics engineering. It innovatively proposes a three-step advanced teaching mode of "enlightenment practice leap", effectively solving the three major difficulties of weak foundation, disconnected practice, and weak innovation. Through this innovative teaching practice, the course group successfully combined "C++Programming and Algorithm Implementation" with the field of robotics. Through theoretical teaching, the foundation was solidified, and open teaching was integrated into enterprise cooperation and project practice to enhance students' programming skills while stimulating innovation awareness and teamwork ability. The innovative teaching mode of the course "C++Programming and Algorithm Implementation" under the background of new engineering not only requires students in the Department of Robotics Engineering to master solid programming foundations and algorithm knowledge, but also emphasizes the application of these skills to practical robotics projects, thereby cultivating students' ability to solve complex engineering problems. This is a long-term and ongoing task that requires teachers to constantly explore new teaching methods and technologies, while also encouraging students to actively participate in practice and face challenges with courage. In the future, the curriculum team will continue to optimize teaching content and methods, introduce more cutting-edge technologies and tools, and strive to cultivate more composite talents who deeply integrate C++programming language and robotics technology that meet the needs of the times.

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