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Teaching Reform and Practice of the Introduction to Robotics Course Based on the Open-Source HarmonyOS and M-Robots OS

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Abstract: Introduction to Robotics is a fundamental core course in robotics programs. Traditional teaching methods suffer from a disconnect between theory and practice, as well as inadequate adaptability of practical platforms. This paper utilizes the open-source HarmonyOS as its technical foundation and integrates the M-RobotsOS robot operating system to analyze the instructional alignment logic and core values of their integration into the curriculum. It identifies existing challenges in content coherence, teaching methodology adaptation, and practical training, and explores reform pathways through curriculum restructuring, teaching model optimization, and practical system development. The findings provide theoretical insights and practical solutions for enhancing teaching effectiveness and cultivating application-oriented robotics professionals.

Keywords: Open-source HarmonyOS; M-RobotsOS; Introduction to robotics; Teaching reform

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1. Introduction

As an introductory course for robotics majors, Introduction to Robotics plays a pivotal role in solidifying students' professional foundation and cultivating engineering practice-oriented thinking. Traditional teaching methods predominantly rely on theoretical instruction, while accompanying practical platforms often exhibit strong isolation and lag behind industrial technological advancements. The cross-device interoperability and open-source nature of HarmonyOS, coupled with the robust compatibility of M-RobotsOS with robotics development, perfectly align with the course's hands-on requirements, serving as a key technological driver for instructional reform. Building upon HarmonyOS and M-RobotsOS, this paper explores teaching innovations for the Introduction to Robotics course, fostering deep integration between theoretical instruction and practical training to enhance students' capabilities in robotics system development and engineering practice [1].

2. The teaching adaptation logic for integrating open-source HarmonyOS and M-RobotsOS into the curriculum

2.1. The integration logic between the open-source HarmonyOS technology foundation and the course knowledge system

Open-source HarmonyOS features distributed software buses and heterogeneous device integration as its core technologies, seamlessly aligning with the knowledge framework of motion control, sensor fusion, and multi-device collaboration in the Introduction to Robotics course. It serves as a technical platform for implementing theoretical concepts. Key course topics, including robotic hardware architecture, software coordination, and human-machine interaction, are concretely demonstrated through HarmonyOS's technical ecosystem, transforming abstract theories into actionable practices that meet both foundational teaching and hands-on training needs. The open-source nature of HarmonyOS overcomes limitations of traditional closed platforms, with its technical documentation, development tools, and curriculum seamlessly integrated. Students can access technical resources through the open-source community to independently explore robotic system fundamentals, achieving deep understanding and flexible application of course content. This precise integration of technical infrastructure and knowledge system shifts teaching from mere theoretical instruction to a dual approach of "theory + technology," solidifying students' professional robotics expertise [2].

2.2. Logic for scenario adaptation between M-RobotsOS and practical robot training settings

M-RobotsOS is a specialized operating system designed for robotics development, professionally optimized for robot motion control, task scheduling, and peripheral driver management. It is highly compatible with the hands-on teaching scenarios of robotics introductory courses, effectively addressing the disconnect between traditional practical platforms and educational requirements. Practical tasks such as basic robot movements, sensor data acquisition, and simple task execution can be rapidly developed and debugged using M-RobotsOS, lowering the entry barrier for students and enhancing the relevance and effectiveness of hands-on instruction. Compatible with the open-source HarmonyOS architecture, M-RobotsOS leverages HarmonyOS's distributed capabilities to enable complex operational scenarios like multi-robot collaboration and robot-intelligent device interconnection, covering all practical needs from foundational to advanced levels. Its lightweight and easy-to-develop nature makes it ideal for university teaching environments, allowing students to complete the entire workflow, from code writing to device operation, in a short timeframe, ensuring seamless and impactful practical learning while cultivating fundamental robotics development skills.

2.3. The empowering logic of dual-platform integration in achieving course teaching objectives

The integration of the open-source HarmonyOS and M-RobotsOS platforms empowers the achievement of course objectives across three dimensions: technical support, practical implementation, and competency development, aligning with the training requirements for applied robotics professionals. The curriculum not only aims to equip students with fundamental robotics theories but also emphasizes cultivating their capabilities in robotic system development, problem-solving, and engineering practice. This dual-platform integration provides a comprehensive technical roadmap, offering concrete tools and platforms for realizing teaching objectives. It leverages HarmonyOS's cross-device, open-source technological foundation while highlighting M-RobotsOS's professional suitability for robotics development, forming a complementary and synergistic teaching ecosystem. Through hands-on experience on both platforms, students solidify their foundational robotics knowledge while mastering cutting-edge development technologies, achieving dual enhancements in both theoretical understanding and practical skills. This approach also fosters professional competencies in open-source collaboration and technical exploration, facilitating the comprehensive fulfillment of course objectives.

3. The core challenges in curriculum teaching reform under the open-source HarmonyOS framework

3.1. Insufficient alignment between course teaching content and the dual-platform technology system

The current introductory robotics course primarily focuses on traditional theoretical knowledge, failing to effectively integrate the core technical frameworks of the open-source HarmonyOS and M-RobotsOS. This results in a disconnect between theoretical concepts and dual-platform technologies. The curriculum lacks systematic explanations of dual-platform architectures, development workflows, and practical applications, offering only superficial operational guidance during hands-on sessions. Consequently, students struggle to grasp the intrinsic connections between theoretical knowledge and dual-platform technologies, hindering their ability to apply knowledge effectively. Although some courses incorporate dual-platform elements, their content organization lacks logical coherence, they do not follow the structured approach of "theoretical knowledge → technical analysis → practical application," leading to fragmented and superficial coverage of dual-platform technologies. Moreover, the teaching materials fail to keep pace with the technological advancements in HarmonyOS and M-RobotsOS, still relying on outdated case studies and development methodologies. This creates a gap between students' acquired skills and real-world industry applications, diminishing the course's technical relevance and forward-looking value [3].

3.2. Inadequate alignment between course teaching models and practical training requirements

The traditional teaching model predominantly relies on "theoretical lectures in class combined with basic hands-on practice afterward," lacking a practical instructional design compatible with dual-platform systems. This approach fails to meet the course's requirement for "deep integration of theory and practice." Instructors focus primarily on explaining theoretical concepts during lectures, offering only brief demonstrations of platform operations, leaving students without real-time practical training in class. Post-class practice also yields poor results due to insufficient immediate teacher guidance, creating a teaching dilemma where students "understand the theory but struggle with practical application." The model lacks effective integration of online and offline learning, as no dedicated online platform supporting dual-platform instruction has been established, preventing students from utilizing fragmented time for technical learning, development exercises, or problem-solving discussions. Additionally, the teaching process remains teacher-centered, with students passively absorbing knowledge rather than engaging in self-directed exploration or collaborative teamwork, making it difficult to cultivate students' technical inquiry skills and collaborative development capabilities, which contradicts the training objectives for hands-on robotics professionals.

3.3. The disconnect between the course practice system and the cultivation of dual-platform development capabilities

The current practical curriculum framework remains predominantly reliant on traditional, closed-ended experiments characterized by simplistic content and monotonous formats, failing to align with the dual-platform development competency requirements of the open-source HarmonyOS and M-RobotsOS. Most practical exercises are verification-based, lacking design-oriented or integrated experiments. Students merely follow experimental manuals without engaging in requirement analysis, solution design, or problem-solving processes, hindering the cultivation of robust robot system development skills across both platforms. The curriculum lacks a tiered progression structure, failing to establish foundational, advanced, and comprehensive practice levels tailored to students 'learning progress and proficiency levels, a gap that leaves weaker students struggling to keep up while enabling more advanced learners to achieve meaningful growth. Additionally, the assessment mechanism remains inadequate, relying solely on experimental reports while neglecting students' development methodologies, problem-solving capabilities, and teamwork performance during practical sessions. This approach fails to comprehensively evaluate dual-platform development competencies and consequently fails to motivate students' active participation in hands-on activities.

4. Core principles for implementing curriculum teaching reform under the open-source HarmonyOS framework

4.1. The synergistic principle of integrating theoretical knowledge with dual-platform practical skills

The reform of course instruction must firmly adhere to the principle of integrating theoretical knowledge with dual-platform practical skills. The distributed technology framework of Open-source HarmonyOS and the robot-specific development architecture of M-Robots OS should be deeply integrated throughout both theoretical and hands-on teaching in the Introduction to Robotics course, creating a mutually reinforcing teaching cycle where "theoretical explanations lay the foundation for practical application, while hands-on training deepens theoretical understanding." Theoretical instruction should focus on real-world application scenarios across both platforms, avoiding purely theoretical lectures detached from practice. Core robotics concepts such as kinematics, dynamics, and sensor fusion should be closely linked to the technical implementation logic of the platforms, demonstrating how theoretical knowledge translates into practical applications, such as device interconnection via Open-source HarmonyOS and motion control through M-Robots OS, to make abstract theories tangible. Hands-on training should be guided by theoretical principles, enabling students to verify and apply theories through practical exercises, thereby enhancing their understanding and mastery. This approach requires abandoning the traditional "separation of theory and practice" mindset in favor of an integrated "theory-technology-practice" framework. Each theoretical concept in robotics should be accompanied by corresponding platform-specific technical analyses and targeted exercises, allowing students to clearly grasp how theories be translated into practice while continuously reinforcing their understanding through hands-on experience. Ultimately, this ensures simultaneous advancement in both theoretical knowledge and dual-platform operational skills, establishing a solid dual foundation in both theory and practice for robotics students [4].

4.2. The principle of aligning course content with technological advances in the robotics industry

The reform of course instruction must strictly adhere to the principle of aligning curriculum content with advancements in robotics technology, keeping pace with the technological iterations of Open-source HarmonyOS and M-Robots OS, while reflecting the industry's trends toward intelligence, modularity, and open-source development. Course materials should be promptly updated and optimized to ensure students acquire knowledge and skills that consistently meet real-world industrial demands, preventing any disconnect between teaching content and practical applications. Curriculum content must incorporate the latest technical features, upgraded development tools, and optimized development workflows from both platforms, alongside cutting-edge industry case studies in industrial, service, and educational robotics. Special sessions on emerging robotics technologies should be included to help students clearly understand technological directions and application scenarios. Upholding this principle requires establishing a regular dynamic update mechanism for course content, with faculty members maintaining regular engagement with the official Open-source HarmonyOS/M-Robots OS communities and leading robotics enterprises to collect the latest technical documentation, development cases, and industry talent requirements, enabling targeted curriculum adjustments. Additionally, standardized development processes, engineering problem-solving approaches, and team collaboration protocols from real-world industries should be integrated into all teaching components, allowing students to experience authentic industrial development scenarios during classroom instruction. This approach fosters early cultivation of industry-specific competencies and engineering thinking, ensuring graduates can swiftly adapt to robotics industry job requirements and achieve seamless integration between academic learning and professional employment.

4.3. The progressive principle of balancing basic teaching with innovation capacity development

The reform of course instruction must consistently adhere to a progressive principle that balances foundational teaching with innovation capability cultivation. Building upon students 'solid grasp of robotics fundamentals and basic development skills using the open-source HarmonyOS and M-Robots OS platforms, the curriculum should follow students' cognitive patterns and developmental trajectories to progressively foster their technical innovation capabilities and engineering practice skills, achieving synergistic growth between foundational competencies and innovative abilities. The teaching process should strictly follow a "foundational–advanced–comprehensive" progression: the foundational stage focuses on explaining core robotics theories and training students in basic platform operations, emphasizing mastery of fundamental robotics concepts, tool usage, and simple module development to establish a solid professional foundation; the advanced stage emphasizes interdisciplinary knowledge integration and comprehensive platform development exercises, guiding students to combine robotics, programming, and electronics expertise to create complex functional modules and cultivate integrated application skills; the comprehensive stage prioritizes innovative design and practical problem-solving training, enabling students to develop solutions for specific robotic application scenarios. Adhering to this principle requires avoiding the pitfalls of "overemphasizing fundamentals at the expense of innovation" or "prioritizing innovation over fundamentals," thereby establishing a tiered, interconnected teaching and practice system. In foundational instruction, emphasis is placed on cultivating students' robotic professional mindset and fundamental practical skills, laying a solid foundation for innovative capability development. In advanced and integrated teaching, through the development of projects on dual platforms that are design-oriented, comprehensive, and innovative, students are guided to engage in independent inquiry and teamwork to solve real-world robotic development challenges independently. This enables students to master basic skills while progressively enhancing their technological innovation and engineering practice capabilities, ultimately transforming them from passive "knowledge recipients" into active "technological innovators."

5. Curriculum reform strategies for M-RobotsOS under the open-source HarmonyOS framework

5.1. Reconstructing the course teaching content system aligned with the dual-platform technology framework

The curriculum has been restructured to align with a dual-platform technology framework, using the core concepts of Robotics Introduction as its foundation. It integrates the distributed architecture and soft bus technology of the open-source HarmonyOS with M-RobotsOS's core capabilities, including motion control, task scheduling, and peripheral drivers, across all course chapters, creating a cohesive teaching framework that combines theoretical knowledge, dual-platform technologies, and real-world industrial applications. The content is organized following the principle of "theory first, technology next, practical application last," ensuring seamless integration between theoretical understanding and platform-specific techniques. Outdated materials unrelated to dual-platform development have been removed, while hands-on components such as tool usage, code writing, debugging, and optimization have been enhanced. Real-world case studies from the robotics industry are incorporated to illustrate the practical applications of dual-platform systems in industrial and service robotics. The curriculum is divided into three modules: a foundational module focusing on theoretical knowledge and basic platform technologies, an advanced module emphasizing interdisciplinary integration and comprehensive platform development, and a comprehensive module dedicated to innovative robot system design under dual-platform environments, achieving a progressive learning progression.

5.2. Developing a blended online-offline teaching model that integrates theory with practical application

We have developed a blended online-offline teaching model that integrates theoretical knowledge with practical application. In offline classrooms, instruction focuses on theoretical explanations, technical analysis, hands-on demonstrations, and problem-solving guidance. Teachers deliver core course content and explain the technical principles of dual-platform systems, enabling students to master basic development operations through live demonstrations. Students receive one-on-one guidance during practical sessions to promptly resolve technical challenges. The classroom emphasizes teacher-student interaction and peer collaboration, organizing group discussions and team projects to cultivate collaborative development skills. An online teaching platform hosts course materials, including theoretical presentations, technical analysis videos, practical tutorials, and development case studies, allowing self-directed learning during fragmented time periods. The platform features real-time features such as online Q&A, assignment submission, code peer review, and discussion forums, facilitating instant communication between instructors and students, as well as peer collaboration on practical assignments and technical discussions. This blended approach transcends temporal and spatial constraints, achieving seamless integration of theoretical knowledge with hands-on training.

5.3. Establishing a hierarchical, progressive practical course teaching system based on dual platforms

We have established a layered, progressive practical teaching system for courses based on dual platforms, structured around the framework of "basic verification experiments–advanced design experiments–comprehensive innovative experiments," with three tiers of practical content tailored to students 'evolving learning capabilities. Basic verification experiments focus on fundamental platform operations and robotics theory validation, such as basic motion control in M-RobotsOS and device interconnection using the open-source HarmonyOS. Advanced design experiments emphasize the integration of multiple knowledge domains and comprehensive platform development, exemplified by sensor data acquisition and processing across both platforms. Comprehensive innovative experiments challenge students to collaboratively design robotic systems under dual-platform environments, requiring team-based efforts that encompass demand analysis, solution design, code development, and equipment debugging aligned with industry needs, such as intelligent service robot design. Additionally, we have refined the practical assessment mechanism by implementing a diversified evaluation system combining "process + outcome," "quantitative + qualitative," and "teacher + student" feedback. Assessment criteria include experimental execution, development proposals, code quality, innovative contributions, and teamwork, with evaluations involving faculty reviews, student self-assessments, and peer assessments to holistically evaluate students' dual-platform practical and innovative competencies.

6. Conclusion

The integrated application of the open-source HarmonyOS foundation with M-RobotsOS provides a groundbreaking technical approach for reforming introductory robotics courses, effectively addressing the core challenge of the disconnect between traditional teaching theories and practical implementation. This paper establishes a research framework comprising four dimensions, teaching adaptation logic, existing key issues, implementation principles, and reform strategies, clarifying the core philosophy and implementation roadmap for curriculum innovation. By restructuring platform-compatible teaching content, developing a blended online-offline instructional model, and creating a tiered practical learning system, the initiative achieves deep integration between dual platforms and course delivery. This approach not only solidifies students' foundational robotics knowledge but also enhances their dual-platform development and engineering practice capabilities, providing robust educational support for cultivating high-caliber applied professionals aligned with cutting-edge technological advancements in the robotics industry.

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