IOSR Journal of Research & Method in Education (IOSR-JRME)
e-ISSN: 2320–7388, p- ISSN: 2320-737x Volume 15, Issue 6 Ser. 3 (Nov. – Dec. 2025), PP 27-36
www.iosrjournals.org

Exploration and Practice of an Integrated Innovation Model for the Microcontroller Curriculum in the Context of Emerging Engineering Education

Chen Chang-xing, Wang Jian-bin
(Faculty of Computer Science and Software, Zhaoqing University, Zhaoqing 526061, China)

Abstract:
As a core engineering course, the traditional teaching methodology for Microcontroller Principles and Applications faces serious challenges in the context of artificial intelligence (AI) and the "Emerging Engineering Education" initiative. Persistent issues include outdated content centered on the limited-performance 8051 microcontroller, a disconnect between theory and practice, monotonous teaching methods, and the underdevelopment of character education. To address these problems, this paper proposes a systematic reform plan. Regarding content, it restructures the knowledge framework around a project-driven approach. Pedagogically, it deeply integrates project-based learning, a flipped classroom model, and a "virtual-physical integration" practical approach to establish a student-centered teaching paradigm. Furthermore, it organically incorporates elements of curriculum ideology and politics throughout the teaching process and establishes a diversified assessment system. Teaching practice demonstrates that this reform plan significantly enhances students' learning initiative, engineering practical ability, and innovative competence. It effectively unifies knowledge imparting, skill cultivation, and value guidance, providing a viable pathway for cultivating outstanding embedded systems talent suited for the AI era.
Key Word*: Microcontroller Curriculum Innovation; STM32; Artificial Intelligence ; Project-Driven Learning; Virtual-Physical Integration*

Date of Submission: 03-12-2025 Date of Acceptance: 14-12-2025

I. Introduction

As a cornerstone course in mechatronics and electronic information engineering, Microcontroller Technology demands a solid theoretical foundation and strong practical skills. Driven by the wave of artificial intelligence (AI) and the national initiatives for "Emerging Engineering Education" and "Golden Courses," curriculum reform is imperative. Although the traditional teaching system centered on the 8051 microcontroller covers fundamental concepts, it struggles to meet the practical requirements for computational power and advanced functionality in intelligent hardware for the AI era.[1]To address these challenges, this paper begins by analyzing the current teaching landscape and reviewing existing reform measures. It then proposes an optimized strategy that integrates an AI-oriented approach. The core of this reform is to upgrade the curriculum content from traditional 8-bit architectures to modern microcontrollers, represented by the STM32 platform, which supports the deployment of AI algorithms. This transition enables students to engage in development for cutting-edge fields such as intelligent sensing and edge computing.

Furthermore, guided by the fundamental mission of fostering virtue and cultivating talent, this study is committed to the organic integration of ideological and political education throughout the teaching process. By embedding values such as building a technologically strong nation, innovation-driven development, and ethical responsibility into concrete AI hardware projects, we achieve a profound synergy of knowledge impartation, skill development, and value guidance. The ultimate aim is to cultivate a new generation of engineers who are not only proficient in smart hardware design but also possess a strong sense of societal duty and national pride.

II. Teaching Status and Problems

(1) Current Teaching Status and Its Foundation

Currently, the vast majority of domestic universities continue to utilize the Intel MCS-51 series microcontroller as the primary platform for the "Principles and Applications of Microcontrollers" course. This situation stems from two primary factors. Firstly, the hardware architecture of the 8051 is relatively straightforward and clear. Its well-defined divisions of the core, memory, I/O ports, and timers/counters make it highly suitable for students to progressively understand the fundamental workings of a computer system.

Secondly, decades of accumulation have resulted in extremely rich teaching resources surrounding the 8051, including a wealth of established textbooks, lab manuals, code examples, as well as low-cost or free development tools and simulation software. This provides tremendous convenience for both teaching and self-study. Consequently, since its introduction in the 1980s, the 8051 microcontroller rapidly gained and has maintained a dominant position in teaching, leading to the establishment of a relatively fixed teaching model.[2]

(2) Core Problem: Disconnect Between Teaching Content and Modern Needs

The central issue in current microcontroller education is the severe disconnect between its content and the demands of the era. On one hand, the 8051, as the mainstream teaching tool, suffers from fundamental limitations due to its 8-bit processor architecture. Its constrained computational power and limited memory capacity are inadequate for handling complex algorithms like image processing and machine learning, or for managing large-scale data processing. Furthermore, it lacks standard modern embedded interfaces like SPI and I2C, preventing students from working with complex sensors (e.g., cameras) in coursework and creating a gap with modern smart hardware applications. On the other hand, the knowledge system itself is narrow and outdated. It overemphasizes understanding the specific hardware of the 8051 and basic programming, while giving scant attention to essential modern embedded development concepts such as modular/engineering programming practices, Real-Time Operating System (RTOS) application, and in-depth practice with bus communication.[3] This creates a generational gap between the students' knowledge structure and modern mainstream 32-bit architectures like ARM Cortex-M, leading to a situation where graduates face a steep learning curve and must spend significant time retraining after entering the workforce.

(3) Rigid Teaching Methods and Weak Practical Components

Microcontroller courses face systematic challenges in both teaching methodology and practical implementation. Theoretical instruction, which encompasses abstract and fragmented prerequisite knowledge from C programming, digital circuits, and sensors, often relies on a traditional teacher-centric, lecture-based approach. This method lacks intuitive demonstrations for complex concepts, resulting in dull classrooms, low student interest, and sustained passive learning.[4]Simultaneously, the practical component is notably weak and disconnected. Lab sessions are predominantly limited to "cookbook-style" verification experiments due to time constraints, with a severe shortage of design-oriented and comprehensive projects. Students merely follow steps to connect wires and fill in code, failing to develop the ability to solve complex engineering problems. Moreover, the weak link between lab content and real-world electronic product development or everyday applications makes it difficult for students to see the practical relevance of their learning, fostering a sense of frustration and the perception that their studies lack utility.[5] Compounding this issue is the contradiction between students' often weak foundational knowledge from prerequisite courses and the inherently dense, challenging nature of the microcontroller curriculum itself. Within limited class hours, instructors are forced to "rush through the material" to cover the syllabus, exacerbating a vicious cycle where poor foundational understanding hinders the grasp of new concepts, ultimately significantly compromising the overall teaching effectiveness.

III. Method and Results

Based on this foundation, the author conducted a large-scale questionnaire survey centered on microcontroller course instruction across several higher education institutions in Zhaoqing. The survey encompassed a diverse range of universities and academic disciplines, which enables a comprehensive representation of the current state of microcontroller education. It is specifically designed to identify prominent issues in this pedagogical context, thereby establishing a basis for proposing effective improvement measures and enhancing classroom teaching quality.

Based on this framework, the questionnaire was designed in two distinct versions: one for students and one for teachers. The student version focused on dimensions such as the introduction of modernized and systematic curriculum restructuring, the implementation of student-centered teaching models, the integration of course content with competitions, and the adoption of comprehensive process-based assessment methods. The teacher version was developed with reference to the Standards for Teachers' Information Technology Application Ability (Trial), with appropriate adaptations to align with the specific characteristics of microcontroller teaching in higher education.

To ensure data objectivity and authenticity, and taking into account geographical, temporal, and other practical constraints, the survey targeted multiple higher education institutions in the Zhaoqing area. A total of 400 questionnaires were distributed—100 to teachers and 300 to students. Among these, 95 teacher questionnaires were returned, yielding a recovery rate of 95%, and 286 student questionnaires were returned, resulting in a recovery rate of 95.3%.

As illustrated in Figure 1, the survey results indicate a highly positive acceptance among both faculty and students toward introducing modernized and systematic restructuring of teaching content into traditional classrooms. This receptiveness was particularly pronounced among students—93% of whom expressed approval (including 78% strongly approving and 15% approving). Similarly, nearly 90% of teachers supported the initiative (72.6% strongly approving and 16.8% approving). The distribution of attitudes shows significant consistency between the two groups, with opposition remaining relatively low (8.4% among teachers and 5.2% among students).These findings highlight both the urgency for optimizing the current teaching system and the broad consensus supporting such reform. They provide a critical foundation for systematically advancing curriculum restructuring, pedagogical innovation, and assessment upgrades. At the same time, the data suggest the need to address the adaptation challenges faced by minority groups during the reform process, emphasizing the importance of establishing an inclusive and progressive pathway for educational ecosystem transformation.

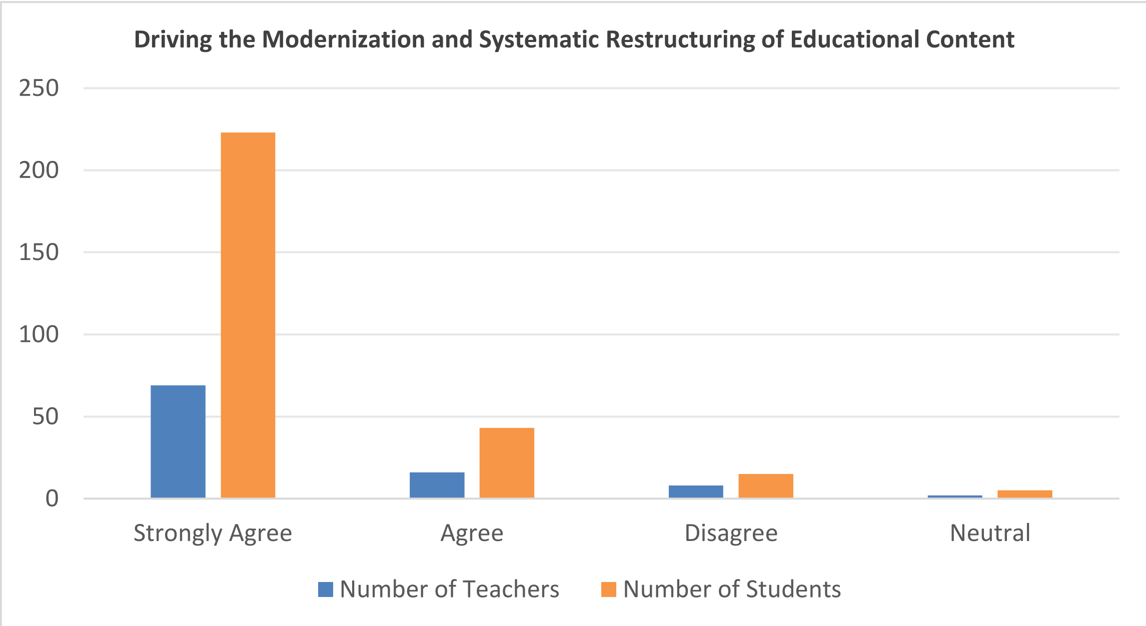

Figure 1: Survey results on the Driving the Modernization and Systematic Restructuring of Educational Content

The survey data provide strong evidence supporting the significant effectiveness of the student-centered teaching model. As shown in Figure 2, an overwhelming majority of the surveyed teachers acknowledged its positive impact across multiple key educational dimensions. Specifically, 95.8% of the participating teachers agreed that this approach effectively enhances teaching quality, while 93.7% recognized its role in promoting quality-oriented education. Similarly high levels of approval were observed in fostering innovation capability (91.6%) and facilitating students' skill development (91.6%). Additionally, 88.4% of respondents confirmed that it significantly increases student classroom engagement. Although "distinctness of teaching effects" received the lowest level of agreement among the dimensions, it was still affirmed by 82.8% of participants. These results clearly indicate that the student-centered teaching model holds distinct advantages over traditional teacher-centered approaches in creating dynamic classrooms, cultivating practical skills, and improving overall educational quality.

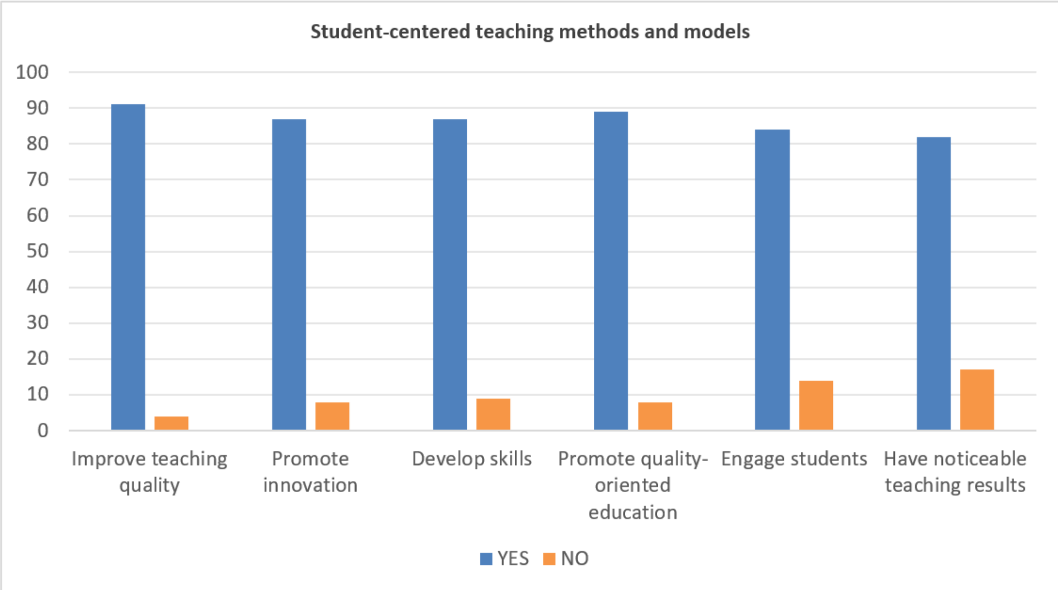

Figure 2: Teacher: Survey results on the Student-centered teaching methods and models

The empirical survey data from the student cohort in this study reveal a strong overall endorsement of the student-centered teaching model, though its perceived effectiveness varies considerably across different dimensions. As shown in Figure 3,The findings demonstrate particularly prominent advantages in cultivating students' practical skills (endorsed by 96.2% of respondents) and fostering innovative thinking (93.7% endorsement), which substantially validates its core educational value. However, the relatively lower approval rates regarding enhanced classroom engagement (77.3%) and distinct teaching effectiveness (70.3%) highlight crucial challenges in practical implementation. These patterns suggest the possible latent and delayed nature of the model's educational impact, indicating that educators should maintain its fundamental strengths while implementing targeted refinements in instructional design and evaluation mechanisms to improve students' learning experience and perception of effectiveness.

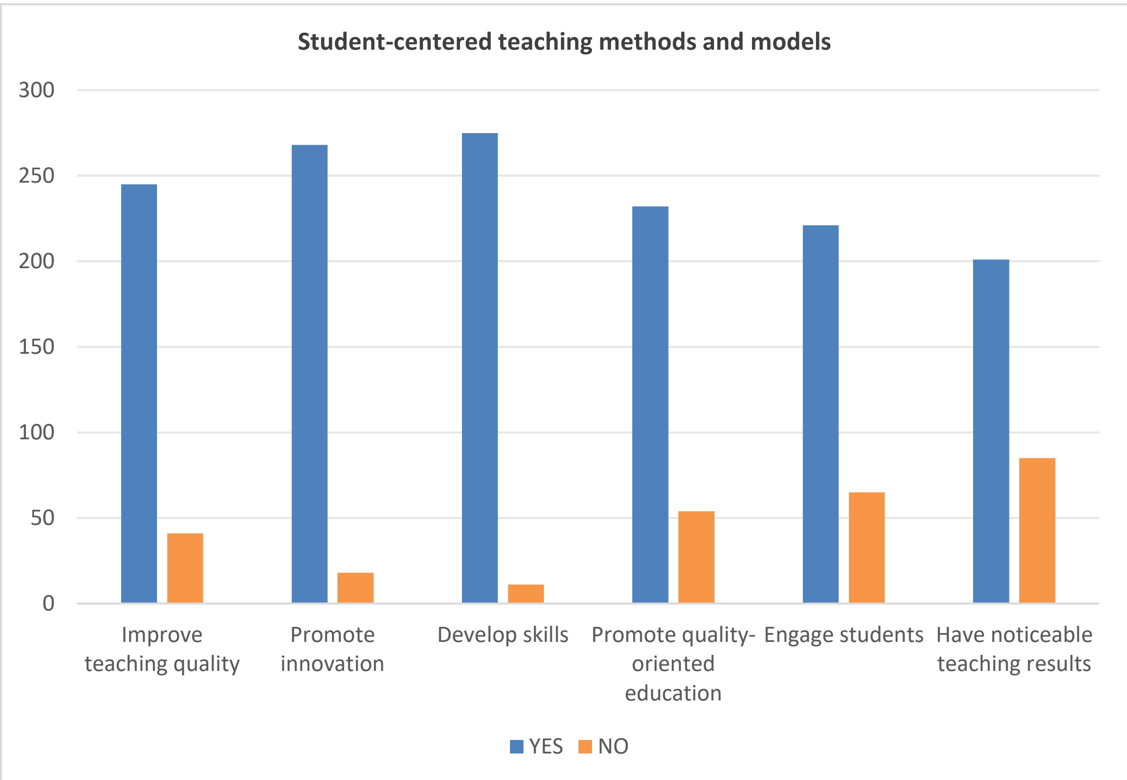

Figure3: Student: Survey results on the Student-centered teaching methods and models

This study evaluated the effectiveness of the educational reforms involving "competition-integrated instruction" and comprehensive process-based assessment through a questionnaire survey administered to faculty members, as illustrated in Figure 4. The data indicate that teachers held a highly positive evaluation of the reform's implementation across various dimensions. Specifically, the highest approval rate of 96.8% (92 affirmative, 3 negative) was observed for "promoting the development of students' comprehensive competencies," suggesting that instructors perceive this model as effective in enhancing students' overall capabilities. In terms of "improving teaching effectiveness," 95.8% expressed approval (91 affirmative, 4 negative), reflecting recognition of the reform's contribution to instructional quality. The dimension of "effectiveness of guidance" received 91.6% endorsement (87 affirmative, 8 negative), indicating teachers' confidence in their instructional roles within the reform framework. Meanwhile, 90.5% of respondents acknowledged the reform's role in "enhancing assessment fairness" (86 affirmative, 9 negative), supporting the view that process-based evaluation provides a more holistic measure of student learning. Regarding "goal alignment," 88.4% approval was recorded (84 affirmative, 11 negative), demonstrating faculty agreement on the coherence between course design and competition objectives. Comparatively, "boosting learning motivation" received a slightly lower yet still dominant approval rate of 77.9% (74 affirmative, 21 negative), suggesting that while teachers recognize its motivational value, they also perceive room for improvement in this aspect. These findings, viewed from the implementers' perspective, validate the overall efficacy of the pedagogical reform and offer valuable insights for further educational innovation.

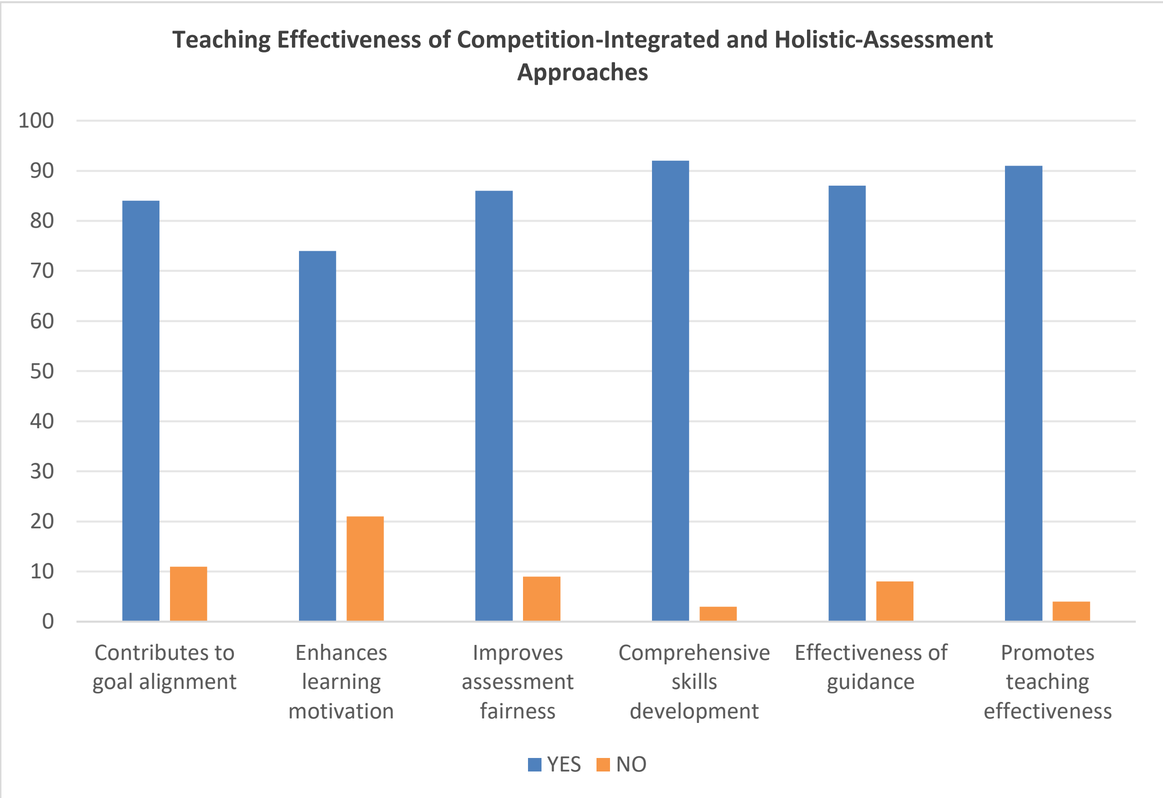

Figure 4:Teacher: Survey results on the Teaching Effectiveness of Competition-Integrated and Holistic-Assessment Approaches

Based on a student questionnaire survey, as illustrated in Figure 5, a comprehensive evaluation was conducted to assess the effectiveness of the teaching reform integrating "course-competition linkage" and whole-process assessment. The data indicate that students generally provided positive evaluations regarding the implementation of this reform across various dimensions, though notable variations were observed among different aspects. Specifically, the dimension of "goal alignment" garnered the highest approval rate of 90.9% (260 affirmative, 26 negative), suggesting that students widely recognize the close integration between course objectives and competition projects. The "effectiveness of guidance" was affirmed by 86.7% of respondents (248 affirmative, 38 negative), reflecting students' approval of the quality of instructor support. Meanwhile, 86.4% endorsed the reform's role in "enhancing learning motivation" (247 affirmative, 39 negative), indicating its positive impact on stimulating student engagement. Additionally, 79.0% acknowledged its contribution to "improving teaching effectiveness" (226 affirmative, 60 negative), demonstrating a general agreement on the reform's role in elevating instructional quality. In contrast, the dimensions of "enhancing assessment fairness" (73.4%, 210 affirmative, 76 negative) and "fostering comprehensive competency development" (71.7%, 205 affirmative, 81 negative) received comparatively lower approval rates. This suggests that while a majority of students acknowledge the overall benefits of the reform, there remains room for improvement in the fairness of the assessment system and the effectiveness of competency cultivation. These findings offer valuable empirical support from the learners' perspective, not only affirming the general direction of the reform but also pinpointing specific areas requiring further optimization.

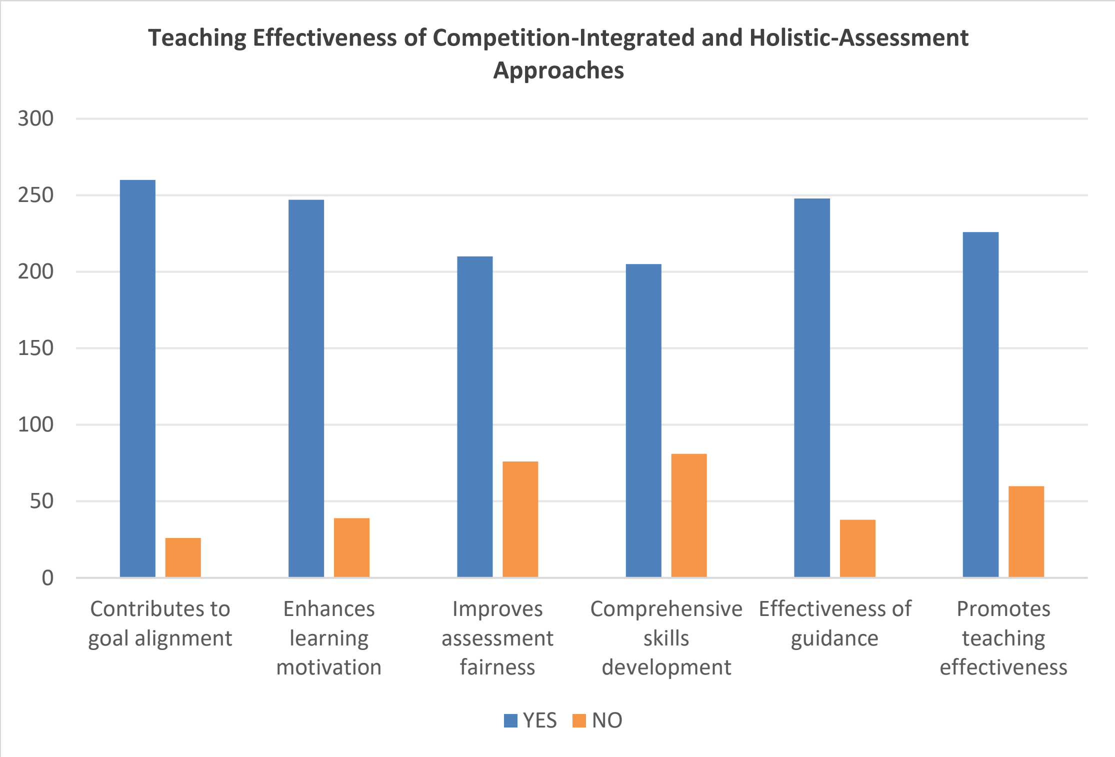

Figure 5:Student: Survey results on the Teaching Effectiveness of Competition-Integrated and Holistic-Assessment Approaches

This survey, centered on the theme of "Organic Integration of Ideological and Political Education into Courses and Enhancement of Faculty Competence," presents a comprehensive analysis of questionnaire data collected from both faculty and student cohorts, as detailed in Figure 6. The findings reveal widespread recognition of the curriculum's ideological and political development across multiple core dimensions, albeit with varying degrees of perceived effectiveness.Notably, the dimension of "promoting students' positive character development" received the highest approval rate (374 affirmative, 7 negative, 98.2%), closely followed by "proactive enhancement of teachers' ideological and political literacy" (365 affirmative, 16 negative, 95.8%). These results demonstrate the significant achievements of ideological and political education in realizing the fundamental goal of "fostering virtue through education" while simultaneously contributing to faculty development.Furthermore, "initiative in theoretical learning among faculty" (350 affirmative, 31 negative, 91.9%) and "enhancement of professional fulfillment" (344 affirmative, 37 negative, 90.3%) both garnered over 90% approval, confirming the dual promoting effect of ideological and political education on teachers' professional growth.In contrast, while "positive impact on character malleability" received 80.8% approval (308 affirmative, 73 negative), the proportion of negative responses was substantially higher than in other dimensions. This suggests that further efforts are needed to deepen the internalization and transformation of students' character through ideological and political education, potentially requiring greater emphasis on implicit educational approaches and long-term developmental strategies.Overall, the data substantiate both the necessity and effectiveness of integrating ideological and political education into the curriculum, while providing clear guidance for optimizing educational models and enhancing the outcomes of moral cultivation.

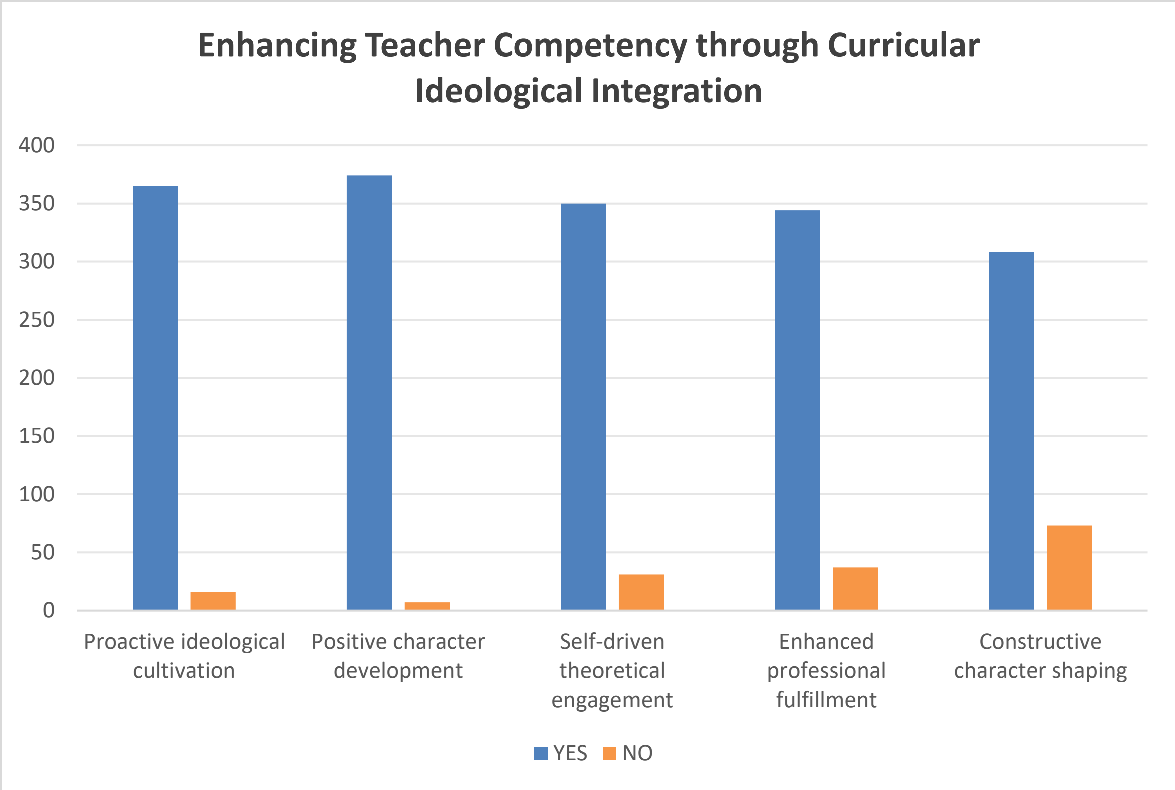

Figure 6: Survey results on the Enhancing Teacher Competency through Curricular Ideological Integration

IV. Teaching Strategy Practice

To address the systematic challenges in current microcontroller education—including outdated core chip architecture, rigid teaching methodologies, the theory-practice disconnect, and insufficient ideological education—a comprehensive reform must be implemented across multiple dimensions: content, methodology, practice, evaluation, and faculty development.

(1) Modernizing and Systematizing Teaching Content

Selection and Updating of Core Content: Building upon the foundational principles of computer systems, a "step-by-step, dual-track approach" is adopted to gradually shift the teaching focus from the traditional 8-bit 8051 microcontroller to 32-bit platforms represented by ARM Cortex-M cores (e.g., STM32). Specifically, in the early stages of the course, the 8051 may still be used to explain basic concepts such as the CPU, memory, and interrupts, as its straightforward architecture helps students build an intuitive understanding[6]. In the mid-to-late stages, the STM32 platform is introduced. By comparing its enhanced processing power, rich peripheral resources (e.g., DMA, multiple UARTs), and advanced development models (e.g., HAL libraries and STM32CubeMX tools), students are guided to transition their knowledge effectively. The updated curriculum is structured around the "main-interrupt" core programming framework and reinforced through concrete examples. For instance, in a "Smart Curtain System" project, students integrate light sensors (I/O applications), timers (for scheduled operation), and motor control (interrupt handling). They also implement FreeRTOS to manage multi-tasking for light monitoring, motor driving, and user interface management, while using the SPI interface to connect an OLED display for real-time environmental data visualization. This instructional design not only covers key knowledge points but also ensures that students' learning aligns with mainstream modern embedded development practices, laying a solid foundation for advanced topics like edge computing and embedded AI.

Implementation of Modularized and Project-Oriented Integration: Moving away from the traditional module-by-module hardware explanation, the knowledge structure is reorganized into teaching modules such as "Basic Input/Output," "Timers and Interrupts," "Communication Protocols," "Sensor Drivers," and "Operating System Fundamentals." Each module's core knowledge is closely integrated with practical mini-projects. For example, when studying UART communication, instead of explaining register configurations in isolation, it is embedded within a "Smart Temperature Control System" project. Students first define the project requirements: receiving temperature setpoints via UART from a host computer and returning real-time collected environmental data. Driven by these requirements, students use tools like "MCU Assistants" to quickly generate framework code for UART initialization and interrupt service routines. This shifts the learning emphasis from memorizing tedious register settings to understanding the principles of UART asynchronous communication, designing data frame formats, handling transmission/reception logic, and addressing practical issues such as anti-interference. By completing a series of interconnected projects like "Traffic Light Control" and "Environmental Monitoring Station," students not only master modular programming concepts through hands-on practice but also systematically develop full-cycle engineering thinking—from problem definition to solution implementation.

(2) Innovating Student-Centered Teaching Methodologies

Enhancing Project-Driven Learning and the Flipped Classroom:A comprehensive project-driven pedagogy is fully implemented, utilizing real-world projects from domains such as smart homes (e.g., smart access control) and environmental monitoring (e.g., PM2.5 detectors). This approach engages students in the complete development cycle, encompassing requirements analysis, hardware selection, software programming, and system debugging. For instance, in a "Smart Warehouse Transport Robot" project, student groups independently integrate an ST32 master control board, motor drivers, infrared line-following sensors, and a Bluetooth communication module, subsequently coding to achieve line tracking, obstacle avoidance, and remote control functionalities. Concurrently, leveraging the flipped classroom model, instructors prepare micro-lecture videos covering critical knowledge points like Timer PWM output and ADC acquisition. Students are required to study these materials before class and submit questions. Classroom time is then dedicated entirely to project discussion, collaborative coding, debugging, and problem-solving, transforming the instructor's role from a lecturer to a facilitator and consultant. This "learning before teaching" model maximizes student autonomy, enabling knowledge to be internalized and reinforced through the process of solving complex problems.

Constructing a Virtual-Physical Integrated Practical Environment:A hybrid experimental environment combining virtual simulation platforms and physical development boards is vigorously developed and utilized. During the initial stages of the course or for complex system design, students are guided to use software like Proteus and Keil to construct virtual circuits and write programs. For example, when designing a "Digital Voltmeter," students can place STM32 models, LCD1602 displays, and variable resistors within Proteus. They then intuitively observe how ADC conversion results drive the display through simulation, iteratively refining the program until it functions correctly. After successful simulation verification, students download the program to a physical STM32 development board for soldering, hardware integration, and debugging, confronting real-world challenges like signal noise and power fluctuations[7]. This approach not only transcends the limitations of physical equipment, space, and time but also reduces hardware damage costs due to operational errors by beginners. Furthermore, the "virtual-before-physical" process cultivates students' comprehensive abilities in system design, software debugging, and hardware troubleshooting more safely and efficiently.

(3) Strengthening Competition-Curriculum Integration and Comprehensive Process Assessment

Establishing a Mechanism for Competitions to Enrich Teaching: We actively organize and encourage students to participate in high-level academic competitions such as the "National Undergraduate Electronic Design Contest" and the "Embedded Chip and System Design Competition," implementing a mentorship model where senior students guide juniors. For example, a dedicated "Embedded Systems Innovation Lab" has been established, where award-winning senior students regularly conduct seminars. They share their experiences in system architecture design, control algorithm implementation, and on-site debugging for classic contest topics like "Wind-Pendulum Control" and "Line-Following Robots." Furthermore, mature competition tasks are simplified and adapted into comprehensive assignments or open-ended experiments within the curriculum, allowing the benefits of contest participation to reach a broader student audience [8]. This model of using competitions to promote learning and foster innovation effectively trains students' innovative thinking, teamwork, and ability to solve complex engineering problems under pressure.

Implementing a Diversified Comprehensive Assessment System: The single-method theoretical examination is reformed by constructing a tripartite assessment system—integrating "Knowledge, Skills, and Literacy"—that runs throughout the entire course. The final grade comprises multiple components: a theoretical exam (30%) assessing grasp of fundamental principles; programming assignments and lab reports (20%) evaluating practical skills and documentation ability; project quality (30% total, broken down into 10% for innovation, 10% for teamwork, and 10% for project outcomes) serves as the core assessment component. Additionally, class participation, online learning progress, and performance in competitions (20%) form the basis for process evaluation. This diversified assessment system can comprehensively and objectively measure students' overall learning outcomes, steering their focus from "test-taking" towards "application."

(4) Deepening the Organic Integration of Curriculum Ideology and Politics and Enhancing Teacher Competence

Achieving Natural Integration of Ideological Elements and Professional Knowledge: We deeply explore the ideological and political elements inherent in the history of microcontroller technology, such as the spirit of struggle, the craftsmanship spirit embedded in programming norms, the scientific spirit required in project debugging, and the ethical responsibilities involved in system design. These elements are then seamlessly integrated, like "salt in water," throughout the teaching of knowledge points, case analyses, and project practice. For instance, when explaining hardware architecture, comparing the development history of domestic and international chip technology can inspire students' ambition to contribute to national technological advancement, while emphasizing timing accuracy cultivates a meticulous and rigorous craftsman spirit.[9] In a comprehensive project like the "Smart Irrigation System," students are guided to consider the social responsibility of water conservation and environmental protection, and the importance of integrity, commitment, and respect for others' work within team collaborations. This "subtle and silent" approach achieves the organic unity of value shaping, knowledge impartation, and ability development.

Promoting the Continuous Updating of Teachers' Instructional Abilities: Teachers themselves must become lifelong learners, keeping pace with the technological frontier. Universities should support faculty in actively learning new knowledge and tools related to STM32, Embedded Linux, edge computing, etc., through measures like establishing special teaching research funds, organizing regular technical training, and building industry-academia partnerships for cultivating "dual-qualified" teachers. For example, teachers are encouraged to attend official ARM or leading industry-organized training during breaks and transform what they learn into teaching cases. Only in this way can teachers bring the latest industry trends, development concepts, and practical cases into the classroom, preventing the teaching content from becoming disconnected from industry needs, thereby providing the fundamental guarantee for the successful implementation of teaching reforms and the cultivation of high-quality, innovative talent.[10]

V. Significant Outcomes and Educational Achievements of the Teaching Reform

Following a series of systematic and in-depth teaching innovations, the course "Microcontroller Principles and Applications" has achieved a leap in teaching quality and yielded remarkable educational outcomes. Firstly, students' learning initiative and innovation capability have improved qualitatively, evidenced by a sustained course attendance rate exceeding 95%. Driven by the project-based learning and competition feedback mechanism, over 70% of students actively participated in comprehensive project development. Record levels of awards and higher rankings were achieved in prestigious competitions such as the "National Robot and AI Competition for College Students" and the "College Student Computer Design Competition." For instance, a student team independently designed an "STM32-Based Intelligent Waste Sorting Bin," which integrated various sensors and wireless communication modules, fully demonstrating their capabilities in hardware-software co-design and complex system integration. Secondly, students' engineering practical abilities and job market alignment have significantly enhanced. Through the "virtual-physical integration" experimental system and project-based training贯穿 the course, students generally became proficient in using modern development tools to complete the entire workflow from requirements analysis to product prototype realization. Graduates have been highly sought after by embedded systems companies due to their solid practical foundation and problem-solving skills. Finally, the implicit educational function of curriculum ideology and politics has been fully realized. Students honed their teamwork spirit through project collaboration, developed a rigorous and pragmatic scientific attitude during debugging challenges, and enhanced their professional responsibility and sense of national purpose when analyzing the societal value of technology. This has truly achieved the organic unity of knowledge impartation, ability cultivation, and value guidance, laying a solid foundation for cultivating outstanding engineers that meet the demands of the new era.

VI. Conclusion

In summary, the teaching of "Microcontroller Principles and Applications" in domestic universities is undergoing a critical transition period. The traditional teaching model, long centered on the 8051 microcontroller and characterized by a theory-practice disconnect, despite its historical reasons, can no longer adequately meet the demands for embedded talent in the era of AI and IoT. Its problems are mainly reflected in outdated content, limited chip performance, monotonous teaching methods, and weakened educational functions. Facing these challenges, teaching reform requires systematic top-level design. The fundamental solution lies in resolutely promoting the strategic shift in teaching content from classic 8-bit architectures to modern 32-bit microcontrollers (e.g., STM32). Centering on this core, a comprehensive reconstruction of the teaching methodology system, characterized by "project-driven learning" and "virtual-physical integration," is essential. By introducing modern educational technologies like project-based learning, the flipped classroom, and virtual simulation, the focus of learning can shift from memorizing fragmented hardware knowledge to cultivating the ability to solve complex engineering problems. Simultaneously, it is imperative to deepen the development of "curriculum ideology and politics," organically integrating value shaping into professional knowledge instruction, and establishing a diversified assessment and evaluation mechanism to comprehensively measure students' knowledge, abilities, and literacy. Practice has proven that only through such multi-dimensional and deep-seated comprehensive reform can we effectively stimulate students' learning subjectivity, cultivate their innovative spirit and practical abilities, and ultimately supply the electronics and information industry with exceptional innovative talent equipped with national sentiment, scientific literacy, and engineering competence.

Funding: This work was supported by the 2025 Zhaoqing University Teaching Quality and Teaching Reform Project (Grant No. zlgc2025029).

References

[1]. Zhuang S .The Application of Generative Artificial Intelligence in Curriculum Reform for Digital Media Technology Programs[J].Scientific Journal Of Humanities and Social Sciences,2025,7(10):8-11.DOI:10.54691/ZBPZQ058.
[2]. Zhao J ,Wu S ,Cao H , et al.Online Teaching Practice of Applied Undergraduate Microcontroller Principle Experiment[J].International Journal of Social Science and Education Research,2025,8(10):365-370.DOI:10.6918/IJOSSER.202510_8(10).0050.
[3]. Yao Y .PLC-Based Teaching of Electrical Automation Microcontroller[J].Curriculum and Teaching Methodology,2022,5(8):DOI:10.23977/CURTM.2022.050814.
[4]. Yeong F C ,Rahman A B H ,Su M L E .A Hands-On Approach To Teaching Microcontroller[J].Journal of Systemics, Cybernetics and Informatics,2013,11(1):55-59.
[5]. University J C C E E A O S W X B Q Y F G ,Hangzhou ,China .The Study of Microcontroller Teaching Method Based on Increasing the Student's Career Ability[C]//Intelligent Information Technology Application Research Association, HongKong,Asia Pacific Environmental Science Research Center, Hong Kong,Wuhan University.2010 International Conference on Optics, Photonics and Energy Engineering (OPEE 2010) （Volume 2）,2010:485-487.
[6]. Khairurrijal ,Munir M M ,Suhendi A , et al.An AT89S52 microcontroller-based single board computer for teaching an instrumentation system course[J].Computer Applications in Engineering Education,2007,15(2):166-173.DOI:10.1002/cae.20107.
[7]. Hudson C .Teaching microcontroller technology - learning through play[C],2001:DOI:10.1049/IC:20010041.
[8]. Koçak E ,Bayır R .Project and group based learning and competition based evaluation in lesson of microcontroller applications[J].Procedia - Social and Behavioral Sciences,2009,1(1):1513-1518.DOI:10.1016/j.sbspro.2009.01.267.
[9]. Bing L ,Yan L ,Wanjun Z , et al.Micro Course Design in the Context of Craftsman Spirit and Innovation and Entrepreneurship Education[J].Advances in Educational Technology and Psychology,2023,7(1):DOI:10.23977/AETP.2023.070117.
[10]. Iskanius P ,Pohjola I.Leveraging communities of practice in university-industry collaboration: a case study on Arctic research[J].Int. J. of Business Innovation and Research,2016,10(2/3):283-299.DOI:10.1504/IJBIR.2016.074830.