Research on the Teaching Reform of "Promoting Teaching and Learning through Competitions" in the Course of Principles and Applications of Embedded Systems: A Case Study of the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition

Kunpeng Ge*, Ziyang Kang, Mingliang Zhu, Jing Yuan, Yujie Wang
College of Information Engineering, Suqian University, Suqian 223800, Jiangsu, China
**Corresponding author.*

Abstract: This paper explores the teaching reform strategies of "promoting teaching and learning through competitions" within the course of Principles and Applications of Embedded Systems, with an in-depth analysis using the Lanqiao Cup Electronics Competition as a case study. Under traditional teaching models, students often passively receive knowledge, lacking opportunities for practical engagement and the cultivation of innovative abilities. In contrast, the model of "promoting teaching and learning through competitions" ignites students' interest in learning through competitive activities, enhancing their initiative in learning and fostering teamwork skills, which in turn improves the quality of education. The Lanqiao Cup Electronic Design Competition, as a prestigious electronic design competition, offers students a platform to showcase themselves and challenge their capabilities. This paper analyzes the specific applications of the Lanqiao Cup Electronic Design Competition within the teaching of Principles and Applications of Embedded Systems, including the integration of competition content with instructional material, the combination of competition projects with experimental teaching, and the incorporation of competition outcomes into teaching assessments. Practical evidence suggests that this instructional model not only enhances students' practical and innovative capabilities but also promotes the improvement of instructors' teaching methods and strategies, providing new ideas and approaches for the reform of the course on Principles and Applications of Embedded Systems.

Keywords: Principles and Applications of Embedded Systems; Promoting Teaching through Competitions; Promoting Learning through Competitions; Teaching Reform; Lanqiao Cup

1. Introduction

The course on Principles and Applications of Embedded Systems plays a crucial role in application-oriented undergraduate education. It not only lays a solid theoretical foundation in electronics and computer science for students but also, more importantly, cultivates their practical skills and innovative thinking through hands-on operations and project-based practice. This course enables students to gain an in-depth understanding of the design and development processes of embedded systems while mastering relevant software and hardware technologies, thereby providing robust support for solving real-world problems [1, 2]. With the rapid advancement of information technology, embedded systems have become indispensable core components across various fields, including modern industry, agriculture, transportation, and healthcare; they function as intelligent "nervous centers", driving the efficient and intelligent operation of diverse devices and systems. The concept of new-quality productive forces refers to the newly formed production capabilities based on advanced technologies such as digitization, intelligence, and networking[3]. However, traditional teaching models often remain confined to textbooks, with relatively fixed curricula that struggle to keep pace with the swift evolution of technology. In such models, students often only acquire foundational theoretical knowledge, lacking awareness of

cutting-edge technologies related to embedded systems and the development of practical skills.

The philosophy of "promoting teaching through competition" refers to the practice of motivating educators to optimize their teaching methodologies via the organization of competitive events. This approach organically integrates course content with competition, effectively enhancing the quality of student learning; in turn, improved learning outcomes encourage students to diligently engage in their studies[4]. By fostering an environment where competitions are utilized to bolster teaching and learning, we can enhance instructors' enthusiasm and simultaneously ignite students' interest in their subjects. Through competitive activities, students gain clearer self-awareness, cultivate a spirit of self-improvement, build confidence in their learning abilities, and strengthen their capacity to apply theoretical knowledge. Additionally, this approach contributes to the development of academic integrity within higher education[5]. The study of Principles and Applications of Embedded Systems closely aligns with the educational concept of "promoting competition through teaching". Both principles work in concert to elevate students' skills and holistic competence. During the teaching process, in-depth exploration of the fundamental principles, design methodologies, and application scenarios of embedded systems not only imparts knowledge but also ignites students' desire for exploration and innovation. The notion of "promoting competition through teaching" underscores the importance of applying theoretical knowledge and practical skills in actual competitions, such as the Lanqiao Cup Electronic Design Competition. This enables students to test their learning in real-world scenarios, confront challenges, and solve problems, thus deepening their understanding and mastery of embedded technology. Moreover, "promoting learning through teaching" emphasizes the significance of interaction and feedback within the educational process, encouraging students to take an active role in their learning. Techniques such as group discussions and collaborative projects facilitate the internalization of knowledge and the enhancement of competencies. In the study of Principles and Applications of Embedded Systems, such a teaching model is particularly vital, as it necessitates that students not only comprehend complex hardware architectures and software programming but also synthesize multidisciplinary knowledge in order to address real-world challenges. Thus, through the dual approach of "promoting competition and learning through teaching", we not only develop students' problem-solving abilities but also stimulate their innovative thinking and collaborative spirit, laying a solid foundation for cultivating high-quality talents adept at adapting to the future demands of technological development.

This study aims to explore how to implement educational reforms in the course on Principles and Applications of Embedded Systems through the philosophy of " promoting teaching through competition". By integrating specific teaching practices, it analyzes effective methods for merging competition with instruction and presents actionable reform proposals, with the intention of providing valuable references and insights for the teaching reform of other courses within the field of electronic information.

2. Educational Reform in the Course on Principles and Applications of Embedded Systems

2.1 Reforming Classroom Instruction

In alignment with the goal of cultivating application-oriented undergraduates, the School of Information Engineering at Suqian University has developed a three-step training plan centered around the Lanqiao Cup competition for students majoring in electronic information. During the first year, students are introduced to EDA (Electronic Design Automation) or competitive projects. The primary objective at this stage is to establish a solid theoretical foundation while cultivating initial practical skills. By engaging in EDA and learning the C programming language, students are inspired to develop an interest in electronic engineering and programming, laying the groundwork for subsequent studies in microcontroller and embedded system development. In the second year, building upon a foundational knowledge of both hardware and software, students will delve into microcontroller technology. They will learn the principles and applications of microcontrollers, enhancing their comprehensive abilities in hardware design and software programming through actual project designs and competitive practices. During the third year,

students will further explore the field of embedded systems by studying advanced technologies such as embedded operating systems, driver development, and network communication. Through participation in higher-level competitions and project developments, they will solidify their preparation for future career opportunities or further academic pursuits.

The Lanqiao Cup Electronic Design Competition is an individual contest with a broad range of awards, making it relatively easy for students to achieve recognition, which significantly enhances their learning motivation and practical skills. To attain better competition results, it is essential to integrate the competition content of the Lanqiao Cup into regular teaching, thereby necessitating a reform of the course on Principles and Applications of Embedded Systems. On the hardware front, the Lanqiao Cup Embedded Systems Design and Development competition mandates the use of the CT117E-M4 embedded training platform as the designated development board[6]. This board features the STM32G431RBT6 microcontroller, developed by STMicroelectronics, which represents a significant upgrade in performance and functionalities due to its Cortex-M3 core. Historically, however, instruction in the course on Principles and Applications of Embedded Systems predominantly utilized the STM32F103 series, necessitating a revision of the course content to reflect this change. In terms of software, the Lanqiao Cup competition specifies the use of STM32CubeMX, a tool that enables developers to configure STM32 microcontroller peripherals, clocks, and interrupts through a graphical interface[7]. This software can automatically generate initialization code and project frameworks, greatly simplifying the STM32 development process. STM32CubeMX is designed to work seamlessly with the HAL (Hardware Abstraction Layer) library, thereby facilitating the combination of graphical configuration and HAL library programming[8]. In prior instructional practices, the use of standard library programming methods placed high demands on students' foundational skills, resulting in less than desirable educational outcomes. Thus, in the teaching process, instructors will utilize the CT117E-M4 embedded training platform as the hardware base, while employing STM32CubeMX in conjunction with the Keil IDE and the HAL library programming approach as the software framework. This integration ensures complete alignment with the requirements of the Lanqiao Cup Embedded Systems Design and Development competition.

Driven by the projects from the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, the teaching of Principles and Applications of Embedded Systems will be undertaken. The competition projects will be subdivided into several modules, each corresponding to a specific educational concept. During the instructional process, theoretical knowledge will be presented initially, followed by practical projects that reinforce the learned material. For instance, when teaching the timer module, a project aimed at controlling motor speed through timing can serve as an illustrative example, enabling students to grasp the programming methods and application techniques associated with timers. Through this project-driven approach, students will gain a deeper understanding of embedded system principles and skills, thereby enhancing their practical abilities and fostering their capacity for innovation.

2.2 Reform of Experimental Teaching

The Principles and Applications of Embedded Systems is a highly practical discipline, where reliance solely on theoretical instruction can impede students' ability to grasp and master its core concepts and technologies. To address this, experimental teaching provides students with invaluable opportunities to translate theoretical knowledge into practical applications. Engaging directly in the design, development, and debugging processes of embedded systems enables students to gain firsthand experience and a deeper understanding of the subject matter. Through hands-on experiments, students can better comprehend the hardware architecture, software programming, and system integration of embedded systems, thereby solidifying their theoretical knowledge. The scoring for the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition illustrates the relevance of such practical experience, with assessments comprising two components: objective and subjective questions. Specifically, objective questions account for 15% of the total score and primarily evaluate foundational knowledge in electronics[9]. In contrast,

subjective questions constitute 85% of the overall score and focus on assessing contestants' practical development and application skills in embedded systems. Participants must demonstrate their ability to complete specific functional developments of embedded systems within the designated time frame while ensuring the correctness and stability of their solutions[10]. This highlights the critical importance of performance on subjective questions, which significantly influences final competition results. Therefore, to achieve remarkable results in the competition, students must excel in the subjective component. As a result, the reform of experimental teaching in Principles and Applications of Embedded Systems is essential, serving a critical role in shaping students' success in competitive contexts.

In the current era of swift technological advancement, to effectively nurture talent in embedded systems that aligns with market demands, we have implemented a thorough reform of the experimental teaching content in the course on Principles and Applications of Embedded Systems, drawing inspiration from the framework of the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition.

First and foremost, the objectives of the experimental teaching have been clearly defined to focus on enhancing students' practical skills, problem-solving abilities, and innovative capacities. We no longer settle for merely validating theoretical knowledge; instead, we prioritize cultivating students' ability to apply embedded principles in real-world projects. By simulating the requirements of the Lanqiao Cup competition, we immerse students in a competitive environment during the experimental process, thereby strengthening their sense of competition and urgency.

In terms of the experimental content, the course has been closely aligned with the focal points of the Lanqiao Cup competition. On one hand, there has been an increased emphasis on foundational experiments related to embedded systems, such as experiments on the characteristics of digital and analog circuits, as well as the identification and use of common electronic components, thereby reinforcing students' foundational knowledge. On the other hand, there has been a heightened focus on programming experiments involving embedded microcontrollers, encompassing programming tasks with mainstream chips like the STM32, including timer experiments, interrupt experiments, and serial communication experiments. Furthermore, practical application projects have been introduced, such as experiments on intelligent home control systems and smart vehicle projects, enabling students to apply their learned knowledge to specific scenarios and enhancing their comprehensive application capabilities.

In terms of the experimental teaching methods, a project-driven approach has been adopted. Students are divided into small groups, with each group responsible for a specific experimental project, engaging in the entire process from requirements analysis and hardware design to software programming and system debugging. In this process, the instructor assumes the role of a facilitator, guiding students to explore independently and solve problems. Additionally, regular inter-group exchanges and sharing sessions are organized to foster collaboration and mutual progress among students.

To more effectively assess students' experimental outcomes, a diversified evaluation system has been established. This system not only examines the results of the experiments but also places significant emphasis on the evaluation of the experimental processes. Factors such as the quality of the experimental reports, teamwork capabilities, and innovative thinking are taken into account. Additionally, students are encouraged to participate in relevant competitions such as the Lanqiao Cup, with competition results serving as a crucial reference for gauging the effectiveness of the experimental teaching.

3. Supportive Measures of Corresponding Policies

3.1 Curriculum and Teaching

Establishment of Relevant Courses or Training: Dedicated training courses or seminars specifically tailored to the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition should be introduced into the school’s curriculum framework. These sessions would cover the principles of embedded systems, pertinent technologies, and analytical techniques for tackling competition problems. For instance, experienced instructors or industry experts could

be invited to provide comprehensive instruction and training to the students.

Course Substitution and Credit Recognition: Students should be permitted to substitute their participation in training, preparation, and competition in the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition for credits in related courses. For example, students who engage in a specified duration of pre-competition training and successfully complete the competition could receive corresponding credits for their professional practice, thereby alleviating academic pressure and encouraging more active participation in competitions.

Adjustment of Course Scheduling: During the period leading up to the competitions, the school could implement appropriate adjustments to the course schedules of participating students, thereby reducing their academic workload and granting them additional time and resources to prepare for the competition. For instance, assignments and examinations for certain courses could be rescheduled to ensure that students can fully dedicate themselves to their competition preparations.

3.2 Rewards and Incentives

Establishment of Special Scholarships: The school could create dedicated scholarships specifically aimed at the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, providing financial rewards to students who achieve outstanding results. The amount and tiers of these scholarships could be determined based on the level of competition and the students' performance, thereby motivating students to participate actively while also recognizing their diligence and commitment.

Honorary Recognition: Students who partake in the Embedded Systems Event in the Lanqiao Cup Electronic Design Competitions should be acknowledged with honorary distinction, such as the issuance of certificates of merit and promotional coverage on the school's official website or campus media. This form of recognition can enhance students' sense of pride and accomplishment, while also fostering a positive competitive atmosphere within the campus and inspiring greater enthusiasm for participation among their peers.

Incentives for Educators: Instructors who guide students in the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition and achieve excellent results should also be rewarded appropriately by the school, perhaps through teaching achievement awards or performance bonuses. Such incentives can encourage educators to dedicate themselves to competition mentorship, thereby enhancing the quality and effectiveness of their guidance.

3.3 Resource Support

Provision of Laboratory Equipment and Facilities: The school should furnish participating students with ample laboratory equipment and dedicated spaces to ensure effective practical operation and training. This could include the opening of the school's laboratories and engineering training centers, outfitted with comprehensive resources such as embedded development boards, sensors, oscilloscopes, and other necessary tools to accommodate students' experimental needs.

Financial Support: The school may allocate financial assistance to participating students for the procurement of materials, tools, books, and other essentials required for the competition. Furthermore, for students entering higher-level competitions such as provincial or national contests, the school could reimburse their transportation and accommodation expenses, thereby alleviating their financial burdens.

Information Resource Support: The school could establish a repository of information resources tailored specifically for the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, compiling past competition problems, exemplary projects, and relevant technical documents for student study and reference. Additionally, the school could provide access to pertinent academic journals and databases to assist students in staying abreast of the latest embedded technologies and industry trends.

3.4 Organization and Management

Establishment of a Competition Guidance Team: The school may form a dedicated guidance team specifically for the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, comprising experienced educators, engineers, and industry professionals. This team can provide students with expert mentorship and training, assist them in formulating competition strategies, resolve technical challenges, and enhance their overall performance in the contest.

Organization of Internal Selection Competitions: The school could regularly host internal selection competitions for the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, identifying exceptional students to participate in higher-level contests. These internal competitions not only afford students the opportunity for practice and showcase their skills but also foster collaboration and learning among peers, ultimately elevating the school's overall competitive standing.

Establishment of a Communication and Coordination Mechanism: Relevant departments within the school should implement a robust communication and coordination framework to address issues and challenges that students encounter during the competition process in a timely manner. For instance, the academic affairs office, student services, and laboratory management departments should enhance their collaboration to provide comprehensive support and resources for the students involved.

4. Conclusion

Guided by the Embedded Systems Event in the Lanqiao Cup Electronic Design Competition, this initiative fosters significant reforms in the teaching of embedded systems courses while simultaneously setting new standards for students' entrepreneurial and innovative capabilities. Through this series of measures, we can effectively enhance students' awareness of independent innovation and their engineering practice skills, as well as refine their proficiency in both software and hardware design analysis. Teaching reform serves as a vital methodology for increasing student engagement and igniting instructors' enthusiasm. By promoting teaching and leaning through competition, we can stimulate students' initiative, enthusiasm, and creativity. This approach also encourages educators to actively participate in pedagogical innovation. Ultimately, the aim is to synergize competition with teaching reform and talent cultivation, thereby genuinely elevating the quality of educational outcomes and nurturing embedded systems professionals who meet the demands of the industry.

Acknowledgments

This research was financially supported by: 1. The Outstanding Course Project at Suqian University: Industry-Education Integrated Course "Frontier Lectures in the Industry" (Project Number: 2024CJRH05); 2. The Tenth Batch of Teaching Reform Research Projects at Suqian University: "Establishing a Practical Teaching System for Cultivating Outstanding Engineers in Electronic Information under the New Engineering Paradigm" (Project Number: SQU2023JGYB09).

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