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Exploration and Practice of the "Cultivation–Growth–Incubation" Talent Training Model in the Master Skills Studio

Zhenjiang Shi*, Junyi Li, Fei Lu

Guangdong Open University (Guangdong Polytechnic Vocational College), Guangzhou 510091, Guangdong, China

**Author to whom correspondence should be addressed.*

Abstract: In the context of the rapid advancement of intelligent manufacturing, ensuring the alignment of the skill levels of embedded system developers with industry requirements has emerged as a crucial aspect in the reform of vocational education. This research delves into a three-stage progressive talent cultivation model denoted as "Cultivation–Growth–Incubation", which is founded on the Shi Zhenjiang (Z. S.) Intelligent Embedded System Development Master Skills Studio. By means of hierarchical training, project-driven strategies, and industry-academia cooperation, this model effectively elevates students' application capabilities and innovative competencies in embedded systems. Case analyses illustrate the practical efficacy of the model, providing valuable references for the establishment of master skills studios in vocational education.

Keywords: Skill master studio; Embedded system development; Talent training mode; Operation mechanism; Industry-education integration

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1. Introduction

As a core technological underpinning for intelligent manufacturing, the Internet of Things (IoT), and industrial automation, embedded systems are experiencing a surge in the demand for talent. Nevertheless, traditional education models are plagued by a disjunction between theory and practice, as well as a skills gap between training programs and industry requirements. This has led to an inadequate supply of embedded technology professionals to satisfy corporate needs. Skill Master Workshops, which serve as crucial platforms for the integration of industry and education in vocational education, amalgamate resources from industry experts, corporate projects, and educational institutions. This innovative approach offers a novel avenue for cultivating technical talents, effectively rectifying the deficiencies in higher vocational education and enhancing teachers' professional capabilities. By establishing school-enterprise collaboration platforms, these workshops substantially elevate the quality of talent cultivation in vocational education [1].

The "Z. S. Intelligent Embedded System Development" Master Skills Studio, spearheaded by provincial-level technical expert Z. S., centers on the development of embedded systems. Upholding the tenets of student skill development, it has formulated a three-stage progressive talent cultivation model of "Cultivation–Growth–Incubation", underpinned by optimized operational mechanisms [2]. This paper scrutinizes the studio's practical experience from three dimensions: model construction, mechanism innovation, and implementation outcomes. It probes into the theoretical underpinnings and core objectives of the "Cultivation–Growth–Incubation" model, elaborating on its implementation framework. The research also explores innovative operational mechanisms, analyzing how dynamic management systems guarantee scientific talent development and how collaborative resource integration boosts training efficacy [3]. By summarizing practical achievements, it emphasizes remarkable feats in enhancing student competencies, aligning talent cultivation with industry requirements, and expanding the studio's brand influence. These findings offer comprehensive references for the establishment of master skills studios in vocational education.

2. The construction rationale and implementation pathway of the "cultivation–growth–incubation" talent cultivation model

In the exploration of the "Z. S. Intelligent Embedded System Development" Master Skills Studio, the three-stage progressive talent cultivation model of "Cultivation–Growth–Incubation" adheres to the phased development law of students' technical skills. Through systematic and step by step guidance, it facilitates students to advance from the accumulation of fundamental knowledge, the improvement of practical abilities, to the stimulation of innovative thinking, thereby attaining comprehensive development.

2.1. Theoretical foundation and core objectives of model construction

2.1.1. Theoretical foundation

The "Cultivation–Growth–Incubation" talent development model is based on the constructivist learning theory and the principles of professional growth. Constructivism posits that learning entails learners actively constructing knowledge systems via practical participation. Professional growth adheres to a sequential trajectory from the acquisition of fundamental skills to comprehensive application, ultimately leading to innovative practice. Capitalizing on the high practicality, rapid iteration, and interdisciplinary characteristics of embedded technology, the studio arranges students' skill development into three interrelated stages: cultivation, growth, and incubation, thus establishing a coherent training framework.

Moreover, the theory of multiple intelligences offers theoretical backing for this talent cultivation model. Every student has distinct combinations of intellectual advantages. In the realm of embedded system development, certain students exhibit excellence in hardware design, whereas others display proficiency in software development. The Master Skills Studio fully respects individual disparities and adopts customized teaching strategies. By means of diversified instructional techniques and project-based tasks at various developmental phases, it activates students' dominant intelligences, allowing each learner to realize their fullest potential in appropriate domains and improve their comprehensive competencies in embedded system development.

2.1.2. Core objectives

The "Cultivation–Growth–Incubation" talent development model is designed to cultivate innovative technical professionals equipped with core competencies in embedded system development and industry relevant expertise [4]. This model encompasses the following aspects: reinforcing students' fundamental knowledge in embedded technology by mastering core skills such as hardware selection and software development; improving their practical project capabilities and teamwork skills to independently accomplish competition tasks or corporate projects; and nurturing students' innovative thinking to formulate problem solving approaches based on technical expertise.

Emphasis is placed on students' understanding of the comprehensive application of embedded systems and their ability to solve practical problems through teamwork when completing challenging competition projects after mastering individual skills.

2.2. Implementation of the three-stage progressive training path

2.2.1. Cultivation group: Consolidate the foundation and establish the technical framework

The advanced training program is tailored for junior students, emphasizing the systematic cultivation of the fundamentals of embedded technology. Employing a "Theory + Modular Training" methodology, the curriculum deconstructs embedded technology into modules, including hardware circuit design, C programming, operating system applications, and sensor interface development. Each module is accompanied by 10–15 practical tasks. For example, in the sensor interface module, students acquire basic data acquisition and signal processing techniques by undertaking projects such as the design of temperature/humidity monitoring devices based on STM32 and the development of infrared remote-control modules.

Additionally, the training group implemented the mentorship system. The core teachers of the studio collaborated with enterprise technicians to compile the "Basic Training Manual of Embedded Technology". This manual delineated the skill objectives, assessment criteria, and learning resources for each module, thereby ensuring the standardization and normalization of the training.

2.2.2. Growth group: Promote learning through competitions and enhance comprehensive application capabilities

The Growth Group focuses on upper-year students possessing foundational skills, providing advanced training via competition-driven projects. The studio selects events such as the "Embedded System Application Development" category in the Guangdong Vocational College Skills Competition and the Internet + Innovation & Entrepreneurship Contest and organizes training through a systematic process, including project decomposition, task assignment, team cooperation, and outcome evaluation. For example, in the preparation for the Guangdong Vocational College Skills Competition, students engage in the "Intelligent Warehouse Robot Control System Development" project, which integrates path planning, motor drive and wireless communication technologies. Through weekly iterations and monthly reviews, they improve their problem-solving abilities.

The growth group adheres to the principle of "Enhancing Teaching via Competitions". It mandates that students document the project development log throughout the training process, encompassing analyses of technical challenges, solutions, and team division of labor. Skill master Shi Zhenjiang conducts regular evaluations of these logs to guide students in cultivating the habit of "Reflective Learning".

2.2.3. Incubation group: Strengthening innovative practical capabilities through school–enterprise collaboration

The incubation program is designed for senior students possessing robust technical proficiency, offering practical training via "Real Enterprise Projects". In collaboration with local smart manufacturing enterprises, the studio initiates product upgrade and technological transformation endeavors, such as the development of embedded modules for industrial equipment monitoring systems and the optimization of firmware for smart home controllers. Students engage in project teams across the entire process, spanning from requirement analysis and solution design to code writing and testing acceptance, under the guidance of both industry engineers and master mentors from the studio.

For example, in a company's "Upgrade Project of Smart Meter Data Collection Module", students from the incubation group optimized the communication protocol of embedded chips. As a result, the data transmission efficiency was increased by 30%, and they obtained technical recognition from the enterprise. These types of projects not only improve students' technical application abilities but also assist them in comprehending the core logic of technology serving industrial requirements.

3. Innovation and practice of the operational mechanism of the skill master studio

Administrative departments at all levels in China have successively promulgated guiding documents regarding the establishment of Skill Master Workshops. The aim is to offer robust policy support for their efficient operation through optimizing resource allocation, enhancing industry-university-research cooperation, and facilitating technical exchanges and innovation [5]. Among these aspects, the innovative operational mechanisms of Skill Master Workshops have emerged as a crucial determinant in promoting the development of high-skilled talent teams.

3.1. Dynamic management mechanism: Ensuring the scientific nature of talent cultivation

3.1.1. Entry and exit mechanism

The cultivation group adopts a model of "Voluntary Application + Basic Test", with the assessment encompassing the fundamentals of electronic circuits and programming basics. The growth group is selected from the cultivation group, stipulating that candidates must complete at least 8 training modules and pass evaluations. The incubation group is chosen from the growth group, demanding the demonstration of competition awards or the ability to complete independent projects.

An exit mechanism of "Quarterly Assessment + Dynamic Adjustment" is implemented. Students who fail to pass the assessment twice consecutively or are absent from training without valid reasons will be transferred to lower-level groups or advised to withdraw, thereby ensuring the enthusiasm of the team.

3.1.2. Assessment and evaluation mechanism

Establish a two-dimensional evaluation system that integrates "Process–Oriented Assessment and Outcome–Based Evaluation". The cultivation group emphasizes three crucial metrics: the quality of module training completion (60%), the comprehensiveness of technical documentation (20%) and the performance of team collaboration (20%). The growth group assesses the outcomes of competition projects (50%), the standardization of technical documents (30%), and the performance of defense presentations (20%). The incubation group employs a dual standard approach that combines "Corporate Evaluations and Technical Indicators", where corporate evaluations account for 60% (including project progress and communication skills) and technical indicators constitute 40% (such as code efficiency and solution innovation).

3.1.3. Reward and punishment mechanism

Awards shall be bestowed upon competition winners via credit recognition and material incentives. Students in the incubation group who successfully complete enterprise projects shall receive performance-based allowances commensurate with their project contributions, and they shall be given priority in employment recommendations. On an annual basis, “Technical Stars” and “Innovation Masters” will be selected. Students who violate studio regulations (e.g., causing equipment damage or project delays) shall be subject to a tiered disciplinary system, including warnings, temporary suspension from project participation, and ultimately expulsion, thereby strengthening the awareness of accountability.

Simultaneously, a creative fund has been established to support students in translating excellent ideas into actual projects. Outstanding teams are provided with opportunities for overseas exchange and learning to expand their perspectives. Through a series of incentive and restraint mechanisms, a positive, rigorous, and realistic learning atmosphere is fostered.

3.2. Collaborative guarantee mechanism: Integrate resources and enhance training efficiency

3.2.1. Daily technical training mechanism

The studio adopts a “5 + 2” training model, specifically, holding two-hour technical seminars every weekday evening and full day project training on weekends. A shared technical platform is established to upload resources including training materials, project codes, and troubleshooting solutions to facilitate self-directed learning. Regular technical salons are organized, during which industry experts share cutting edge technologies such as embedded AI algorithms and edge computing applications, thereby expanding students’ horizons. Through practical case studies, new technologies are expounded in an accessible manner with respect to their real-world applications and implementation methods in embedded system development, guiding students to incorporate these advanced technologies into their own projects.

Additionally, the studio conducts a technical assessment on a monthly basis, encompassing the theoretical knowledge and practical skills acquired within the current month, with the aim of comprehensively evaluating students’ learning status. Teachers consistently adjust the training plan in accordance with the assessment results to guarantee the stable enhancement of students’ knowledge and skills.

3.2.2. Management mechanism for enterprise technical service projects

In the project planning stage, a project coordination team should be established to clarify requirements with enterprises, determine timelines, and sign project responsibility agreements. The team is required to conduct a comprehensive needs analysis to guarantee a clear comprehension of the enterprise’s project objectives, functional specifications, and performance criteria. When determining timelines, the complexity of the project, the skill levels of students, and potential risks should be fully taken into account, and tasks and deliverables should be strategically arranged across different phases.

In the project implementation stage, a “Weekly Meeting + Progress Report” system is implemented. The project leader provides updates that comprehensively detail the tasks accomplished, the challenges encountered and their corresponding solutions, along with the subsequent steps. Progress reports are required to precisely mirror the actual project timelines, thus offering a foundation for monitoring and making adjustments. By means of this approach, students acquire the ability to complete tasks within the stipulated deadlines, thereby improving both project management competencies and teamwork capabilities.

In the project summary stage, corporate representatives and school administrators are invited to participate in the project outcome presentation, during which students showcase their achievements and receive feedback. Students are required to precisely expound on the project’s background, objectives, technical solutions, implementation process, and final outcomes, while highlighting their contributions and learning gains. This presentation functions as a vital means for students to reflect on their experiences and pinpoint areas for enhancement, which will facilitate their continuous development in future academic and professional pursuits.

3.2.3. Knowledge sharing and collaboration mechanism

The studio has instituted a mentorship mechanism in which senior students act as technical advisors for junior members, thereby establishing a practical learning milieu. Monthly technical seminars are arranged to promote knowledge dissemination. During these seminars, participants showcase their recent accomplishments or project experiences, such as optimizing multi task scheduling in FreeRTOS based systems and formulating low power design methodologies for embedded systems, which facilitates collaborative knowledge interchange.

The online knowledge sharing platform developed by the studio empowers students to upload study notes, project codes, technical documents, and other materials for mutual learning. Equipped with categorized directories and search capabilities, it enables effective resource exploration. Moreover, the platform incorporates specialized discussion forums where students can exchange perspectives, pose queries, and engage in collaborative deliberations with their peers.

The studio systematically arranges team project activities to promote collaboration among students. In these projects, participants engage in collaborative efforts according to their respective strengths and professional expertise to accomplish tasks. Through such teamwork, students not only enhance their technical proficiencies but also cultivate a spirit of teamwork and communication capabilities. After project completion, students exchange their perspectives and experiences, summarize the lessons learned, and apply these learnings to more effectively utilize team strength in future academic pursuits and professional endeavors.

4. Practical outcomes

4.1. The skill levels of students have been notably enhanced

In the past two years, the studio has trained 50 students, among whom 30 have joined the Growth Group and 15 have entered the Incubation Group. Students in the Growth Group have achieved 21 awards in national and provincial skills competitions, specifically including 2 third place awards at the national level, 2 first place awards and 3 second place awards at the provincial level, along with 14 third place awards at the provincial level. The Incubation Group has completed 5 corporate projects, yielding direct economic benefits exceeding 200,000 yuan for partner companies.

4.2. Talent cultivation is precisely aligned with industrial requirements

By integrating state of the art technologies and leveraging real industrial project cases, the studio has improved the practical skills and innovation capabilities in talent cultivation. It has also provided the society with a substantial number of high-quality talents equipped with international perspectives and innovation capabilities.

Based on follow up surveys, the employment rate of the studio's graduates reached 100%. Among them, 85% were employed by enterprises in the intelligent manufacturing and IoT sectors, taking on positions such as embedded development engineers and hardware testing engineers. Company feedback indicated that graduates from the studio exhibited rapid adaptability and strong problem-solving abilities, with a probation period pass rate 40% higher than that of regular graduates.

4.3. Enhance the brand influence of the studio

Since the implementation of the "Cultivation–Growth–Incubation" model, a replicable experience framework has been established. The studio has received visits from five sister institutions for academic exchanges. In the process of the development of the Master Skills Studio, faculty members have considerably improved their professional knowledge and technical abilities [6]. Significantly, the innovative teaching methods developed by the technical team led by Master Skills Expert Shi Zhenjiang have gained extensive acclaim, enabling the studio to be awarded the prestigious "Innovative Teaching Faculty Team" honor by the university. This accomplishment has significantly enhanced the studio's industry reputation and academic influence.

5. Conclusions

The "Cultivation–Growth–Incubation" talent development model has realized systematic training for embedded technical professionals via a hierarchical progression of cultivation approaches and a scientifically rational operational mechanism. Under the guidance of master technicians, implemented through project - based practice, and supported by school-enterprise cooperation, this approach effectively resolves the disjunction between academic learning and practical application. It offers a practical framework for the establishment of master technician studios in vocational education.

In the future, the studio will further strengthen the integration of industry and education, optimize the training model and operational mechanism, endeavor to cultivate higher quality technical and skilled talents that meet industrial requirements, and contribute to the development of the intelligent manufacturing industry.

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