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# PIECE: A professional and innovative entrepreneurial integration education model

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**Abstract:** To cultivate high-level engineering and applied talents capable of adapting to the IT industry, the School of Computer Science at Shandong University of Technology has proposed the PIECE skill progressive cultivation teaching model. This model takes project practice as the main line, combines innovation and entrepreneurship education, and stimulates students' practical and innovative abilities through competitions. The curriculum design focuses on the decomposition of projects, the integration of professionalism and innovation, and the enhancement of project capabilities, aiming to improve students' ability to solve practical problems. This teaching method not only strengthens students' professional knowledge but also cultivates their independent thinking and innovative problem-solving abilities, laying a solid foundation for becoming professional talents in the future IT field. Through this cultivation model, students can better adapt to the rapidly changing technological environment and meet the industry's demand for high-end technical talents.

**Key words:** PIECE teaching model; innovation and entrepreneurship education; competition-driven learning, internet of things technology; integration of specialization and innovation in teaching reform

## 1 Introduction

To cultivate high-level engineering application talents who can undertake the design, development, operation, and management of IT software and hardware systems, the School of Computer Science has built ten major innovation and open laboratories such as ACM and the internet of things since 2013, implementing a "competition-driven learning" teaching model, and has achieved a series of teaching results. However, there are the following problems: (1) Given the rapid development of IT technology, the teaching content is lagging. Students lack sufficient opportunities to exercise new technologies, leading to insufficient ability to connect theory with practice, low practical ability, weak ability to solve complex engineering problems, and a disconnect with social needs [1]; (2) The professional training system lacks innovative teaching methods, resulting in low-quality IT works designed by students, limited innovative functions, weak commercialization, and the need to improve students' document writing ability [2]; (3) Influenced by traditional assessment methods, students' IT works are mostly aimed at competition awards, lacking the courage and confidence to challenge high-level achievements such as academic papers, national-level innovation projects, patents, and software copyrights [3].

To address this issue, the major implemented the teaching reform of "whole-process engineering education professional certification and computer professional integration construction for all students" in 2019, and tried a

PIECE-based integration teaching model in practical IT courses, which was approved as a research project for Shandong undergraduate university teaching reform in 2021.

## 2 PIECE specialized integrated teaching model framework

PIECE, a teaching model initiated at Shandong University of Technology since 2013, focuses on nurturing top-tier engineering talents for IT systems design, development, operation, and management. It leverages projects, innovation, entrepreneurship, and competitions to foster excellent engineers, enhancing students' innovation and entrepreneurship skills and aiding in engineering education accreditation [4]. The framework is depicted in Figure 1.

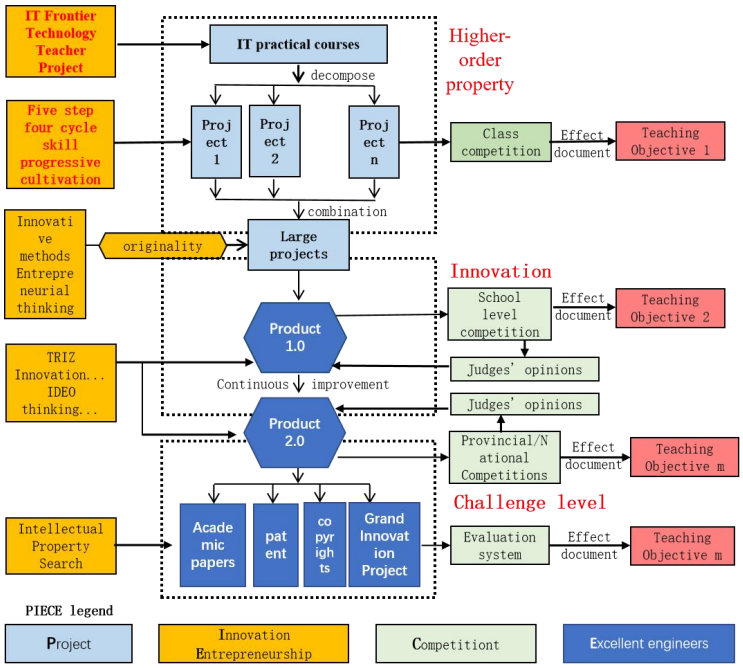


Figure 1. Schematic diagram of the implementation framework of the PIECE teaching model

The PIECE model, exemplified by its application in "Internet of Things Technology and Project Design", involves selecting IT practice courses to achieve an integrated project goal. Lead teachers with engineering backgrounds decompose the project into smaller tasks, restructure course content, and guide students through teaching, demonstrations, verifications, quizzes, experiments, and lab work to make students master the necessary technologies. Each sub-project is assessed via in-class competitions, with students integrating the technologies to execute the full project. Innovation and entrepreneurship elements like IDEO design thinking and TRIZ methods are integrated into project stages, leading to a product 1.0 and mandatory participation in school competitions to enhance students' innovation skills [5]. Post-project, competitive works are advanced to provincial or national competitions, with students encouraged to write papers, apply for patents, and undertake innovation projects, fostering a spirit of self-transcendence.

## 3 Implementation plan for comprehensive course projects

The specialized integrated teaching framework of PIECE mode, as demonstrated in the "Internet of Things Technology and Project Design" course at SUT, aims to equip students with the skills to execute comprehensive projects through a professional IT practice course. This core course integrates IoT theory with practical application, focusing on foundational knowledge, data management, and independent task execution, while promoting teamwork, project management, and IoT innovation. It is led by a teacher with project experience in areas like real-time management platforms and medical equipment monitoring systems. The course is structured into 18 demonstration/analysis mini-projects, 18 simulation training mini-projects, 5 testing projects, and 3 design experiments, covering all course objectives

and enabling students to design integrated projects upon completion of the course, which has been approved as a provincial-level educational reform project.

① Eighteen demonstration/analysis mini-projects are demonstrated/analyzed by the lead teacher during class. After the demonstration/analysis, students complete the corresponding eighteen simulation training mini-projects. There are no standard answers for these projects; only tasks and indicators are provided. Students must complete 80% of the mini-projects to be eligible for assessment.

② Five testing projects and three design-type experiments are conducted in the form of class competitions. The class judges (including teachers) inspect the projects. After meeting the functional quantity and quality standards, the order of completion will be announced, and grades will be awarded based on the time spent on the design. Figure 2 is a screenshot showing the public results of the order in which students completed Experiment 1 through a competitive approach.

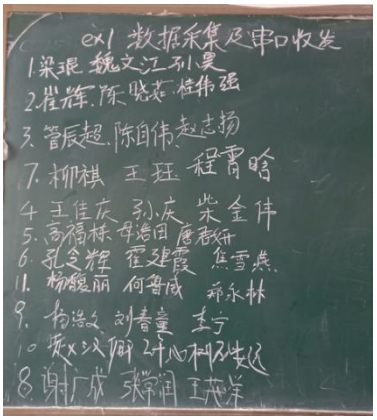

Figure 2. Sequence of student completion

## 4 Specialized integrated implementation plan

In the second part of the PIECE specialized integrated teaching model framework, it briefly explains how to enable students to gain the ability to implement an integrated project through the study of a professional IT practice course. The following is the specific implementation process of the course "Internet of Things Technology and Project Design".

It is a key, innovative course, emphasizing practical operation to develop the understanding of IoT theory and architecture. It covers data tech, encourages teamwork, project management, and IoT system innovation, fostering skills in computation, analysis, design, simulation, experimentation, and entrepreneurial thinking.

After the course leader participated in the training of "Secondary Certification in Compliance with the Requirements of the International TRIZ Association" and the "Innovation and Entrepreneurship Mentor Development Program", a model for the deep integration of innovation methods, entrepreneurial thinking, value engineering, and IT practice course projects was proposed, as shown in Figure 4 .

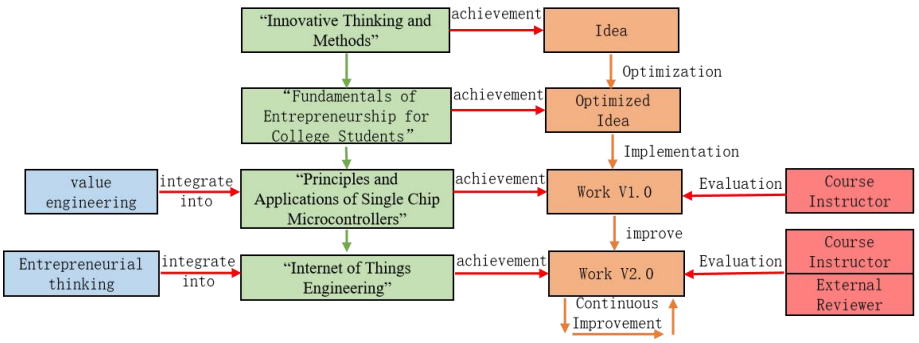


Figure 3. Integration model of entrepreneurial thinking and course practice projects

The students' projects incorporated innovation and entrepreneurship, leading to improved and competitive entries in school contests like SUT's Embedded/IoT Tech Competition. Table 1 shows how to embed these concepts in project design.

Table 1. Models for integrating the project design phase with specific methods and theories of innovation and entrepreneurship

| No. | Teaching link | Current teaching methods | Theory of innovative and entrepreneurial methods to be integrated | Integrated teaching methods | Expected teaching effect explanation |
|---|---|---|---|---|---|
| 1 | Grouping | Free grouping | Team thinking, equity thinking | Add a grouping explanation table, including project objectives, division of labor, and cooperation methods | Based on common goals, learn to divide work and cooperate, enhance team awareness and dedication spirit |
| 2 | Selected topic | Student choice | Pain point thinking | Add a pain point discrimination table to distinguish the authenticity of pain points based on their breadth, frequency, and intensity | Master the classification of strong pain points, weak pain points, and pseudo pain points, and then be able to select topics. |
| 3 | Investigation and research | Conduct 1-2 surveys | Value proposition thinking | Analyze from the aspects of performance, novelty, usability, etc | Conduct research with a down-to-earth approach |
| 4 | Data acquisition | Demo, Design | Business model thinking, TRIZ innovation method (such as feedback method) | Increase cost accounting, innovative solutions for increasing design | Enhance students' cost awareness, improve students' TRIZ innovation ability |
| 5 | Data transmission | Demo, Design | | | |
| 6 | Data display | Demo, Design | TRIZ innovation method (such as replication method, color method, substitution method) | Innovative solutions for increasing design | Improve students' TRIZ innovation ability |

| | | | | | |
|---|---|---|---|---|---|
| 7 | Paper writing | Sample paper | Team thinking, brainstorming | Add a task division table, including analysis of paper division of labor and standardized organization | Continuous standardization of text and charts, continuous improvement of organization |
| 8 | Defence | Presentation and defense | Elevator speech thinking | Subdivide the various parts of the defense and assign responsibilities to each individual, refine each PPT | Everything should go straight to the point, go straight to the result, and take the shortest time |

The aforementioned integration model enables students to master innovation and entrepreneurship theories and methods, organically integrate them into various projects (including products), thereby significantly enhancing students' capabilities.

## 5 Conclusion

Since PIECE's implementation:

(1) The CS major was designated as a provincial "professional service" project in 2018 and a national "first-class undergraduate major" in 2020; the SE major was recognized as a provincial "first-class undergraduate major" in 2019.

(2) Team members have undertaken 21 provincial and ministerial teaching research projects, won the 2nd prize in Shandong's teaching achievements and five school-level awards.

(3) In Chinese college students computer competition, students have consistently ranked in the top ten against 985 universities; they've won 60% of the school's A-level events. Major students have published 20 papers as first authors, obtained 2 utility model patents, and over 30 provincial-level or above innovation and entrepreneurship projects.

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## Conflicts of interest

The author declares no conflicts of interest regarding the publication of this paper.

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