Research on the Innovative Application of the OBE-based TTWO Project-based Teaching Model in Higher Vocational Technical Courses

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[**Abstract**] To address the problems of emphasizing process over results and projects over outputs in project-based teaching in higher vocational education, this study identifies the disconnection between the teaching process and output capabilities as the root cause. It proposes deeply integrating the Outcome-based Education (OBE) philosophy with project-based teaching and constructing the TTWO (Target, Training, Working, and Outcome) model. Guided by outcome orientation, continuous improvement, and student-centeredness at the top level, the model achieves precise alignment between teaching and vocational requirements through project skill decomposition, baseline establishment, and a closed-loop process. Using the Simple Household Intrusion Detection System project in the course Design and Implementation of IoT Nodes as the vehicle, the study verifies that the model effectively improves students' technical application, innovative thinking, and teamwork capabilities, providing a practical paradigm that can be promoted in higher vocational teaching reform.

[**Key words**] OBE philosophy; TTWO model; project-based teaching; technical courses; output capability; higher vocational education

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1 Introduction

1.1 Research background and problem statement

As industrial transformation and upgrading continue to raise the demand for technical and skilled professionals, competency-based teaching reform in higher vocational education has entered a critical stage. Project-based teaching, as an effective pathway linking theoretical knowledge with professional practice, is widely used in technical course instruction. However, most current project-based teaching still follows the traditional logic of project-driven learning, theoretical study, and practical implementation, revealing several structural contradictions in practice. Traditional project-based teaching often emphasizes the completeness of the learning process and treats project implementation as the instructional core, while overlooking the fundamental objective of whether learning outcomes can be transformed into professional outputs. As a result, students may participate in project practice but still lack the output capability required to solve real workplace problems. The teaching process is dominated by the

project itself, while project design is often based on the course knowledge system rather than the output requirements of professional positions. This causes teaching activities to deviate from the output-centered nature of vocational education and creates a disconnect between knowledge and skills training and workplace application. Existing assessment mainly consists of formative and summative evaluations during project implementation and focuses on whether students complete project tasks. It has not established evaluation criteria centered on output quality and application value, making it difficult to measure students' professional competence effectively. Project design is also dominated by verification and repetitive tasks, with insufficient guidance for comprehensive and innovative thinking. Consequently, students may find it difficult to adapt to industry innovation and the demand for creative talent.

1.2 Current status of research at home and abroad

The application of the OBE philosophy abroad has developed into a mature system. Countries such as the United States and Australia regard it as a core concept for quality assurance in higher education and widely apply it in accreditation of engineering programs, forming a closed-loop mechanism of goal setting, implementation, outcome evaluation, and continuous improvement. Chinese scholars have conducted extensive exploration of applying OBE in higher vocational education. Chen Suping and colleagues proposed a discipline-based project learning design framework, emphasizing the organic integration of projects and disciplinary knowledge. Lin Lin and colleagues introduced the STEM education philosophy and explored ways to integrate innovative thinking into classroom instruction. However, existing studies mostly focus on reforming individual links and lack a systematic reconstruction of the entire project-based teaching process. A closed-loop teaching model that balances standardization and flexibility has not yet been established, making it difficult to address the core problem of insufficient output capability development in traditional teaching.

2 Theoretical construction of the OBE-based TTWO project-based teaching model

2.1 Core connotation

The core of the OBE philosophy is to take students' learning outcomes as the guide and ensure that students achieve expected goals through continuous improvement. In essence, it is a closed-loop system of goal orientation, process control, outcome evaluation, and continuous improvement. The TTWO project-based teaching model uses OBE as its top-level design and divides project-based teaching into four core stages: Target, Training, Working, and Outcome. It constructs a three-dimensional teaching structure of OBE top-level control plus TTWO bottom-level execution, as shown in Figure 1.

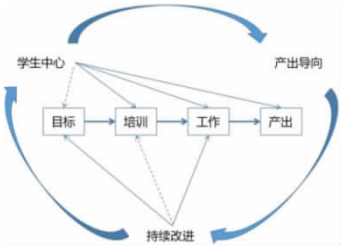


Figure 1 Three-dimensional teaching structure of "OBE top-level control + TTWO bottom-level execution"

The OBE top-level control layer uses outcome orientation, continuous improvement, and student-centeredness as its circular logic to define the core teaching objectives and quality standards. The TTWO bottom-level execution layer follows the implementation path of target establishment, skills training, project implementation, and outcome production to ensure the orderly advancement of teaching. The two layers interact to form a closed-loop teaching mechanism of goal guidance, process assurance, outcome verification, and feedback-based optimization, thereby achieving precise alignment between the teaching process and vocational output requirements.

2.2 Operating mechanism

TTWO organically combines three mechanisms: goal orientation, student-centeredness, and continuous

improvement. Goal orientation takes the output requirements of professional positions as the basis and structurally decomposes knowledge points and skill points to establish the project baseline and teaching objectives, ensuring consistency between teaching content and workplace competency requirements. The student-centered mechanism respects students' active role and meets differentiated learning needs through modular training, division of labor, collaboration, and individualized outputs. Under the continuous improvement mechanism, process monitoring, outcome evaluation, and feedback optimization dynamically adjust teaching objectives, training content, and project design, forming a closed-loop optimization process of implementation, evaluation, improvement, and re-implementation.

2.3 Implementation process

The implementation of the TTWO project-based teaching model follows a six-step closed-loop process:

The first step is to structurally decompose knowledge points and skill points to provide a basis for designing subsequent training content and establishing the project baseline. Its component modules are shown in Figure 2.

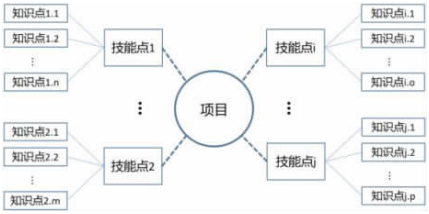


Figure 2 Component module diagram of project knowledge points and skill points

The second step is to establish the project baseline and objectives, as shown in Figure 3. The baseline is determined by combining the results of knowledge-point and skill-point decomposition with students' cognitive levels and represents the minimum output standard that students must achieve. If the proportion of individual students failing to reach the baseline exceeds the acceptable control range, or if a student team fails to meet the standard, the baseline should be adjusted downward in a timely manner. With exceeding the baseline as its orientation, the project clarifies its application area, core functions, technical essentials, and completion process.



Figure 3 Schematic diagram of the outcome-focused baseline (project baseline)

The third step is to use modular skills training, loose-leaf teaching materials, and a blended training model that combines online resources with on-site guidance. With knowledge-point and skill-point components as the basis and modules as training units, it organically integrates knowledge learning and skills training, as shown in Figure 4.

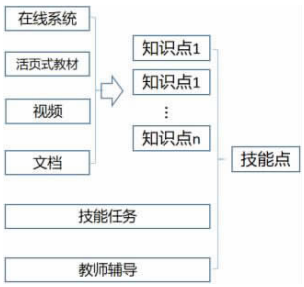


Figure 4 Schematic diagram of skill-point element-driven training

The fourth step is contextualized project work. Student groups divide responsibilities and collaborate according to the project objectives and implementation process to complete project design, hardware production, software development, and system testing, as shown in Figure 5.



Figure 5 Capability assessment during the working stage

Teachers adopt differentiated guidance strategies according to the capability levels of different groups. For groups with stronger capabilities, teachers provide extension tasks and expand learning opportunities for the group as a whole. For groups with weaker capabilities, teachers provide targeted intervention to ensure that they reach the project baseline.

The fifth step is diversified outcome evaluation. As shown in Table 1, a diversified evaluation system that includes process evaluation, peer evaluation of outcomes, teacher evaluation, and enterprise evaluation is constructed. Process evaluation focuses on collaboration and task completion during project implementation. Peer evaluation is conducted by students through presentation - based demonstrations. Teacher evaluation comprehensively assesses outputs from the dimensions of technical complexity, application value, and practicality, with particular attention to the extent to which outputs exceed the project baseline. The enterprise's final evaluation focuses on the potential practical application effect of the completed project outcomes.

Table 1 Example of a diversified outcome evaluation system

Evaluation dimension	Evaluation content	Evaluator	Weight
Process evaluation	Task allocation, collaboration, progress control, problem solving	Teachers + groups	30%
Peer evaluation of outcomes	Presentation, completeness, innovation	Student group leaders + members	20%
Teacher evaluation	Technical complexity, application value, practicality, document standardization	Teacher team	30%
Enterprise final evaluation	Final project outcomes	Enterprise mentors	20%

The sixth step is summary, feedback, and improvement. Based on student project summaries, on-site teaching records, and outcome evaluation results, the process is comprehensively reviewed from the aspects of objective setting, training content, project design, and implementation. The resulting feedback and improvement report provides a basis for subsequent teaching optimization and realizes continuous improvement of the teaching process.

3 Practical application of the TTWO project-based teaching model: a case study of the course Design and Implementation of IoT Nodes

3.1 Course background

Design and Implementation of IoT Nodes is a core course for students majoring in IoT Application Technology at Wuhan Vocational College of Software and Engineering. It aims to develop students' introductory abilities in designing, developing, and debugging IoT nodes. The course content is closely connected with the National Vocational College Skills Competition and innovation and entrepreneurship practice. Project 3, Simple Household Intrusion Detection System, was selected as the practical vehicle. The project covers core skills such as hardware circuit design, embedded software development, and system debugging, and is consistent with the cognitive level of higher vocational students and workplace requirements.

3.2 Practice process

3.2.1 Structural decomposition of project knowledge points and skill points

The Simple Household Intrusion Detection System project is decomposed into five component modules: a

button module, an LED module, a buzzer module, a photoelectric module, and a core system module. Each module contains corresponding knowledge points and skill points, as shown in Figure 6.



Figure 6 Structural decomposition of knowledge-point and skill-point components

The button module is newly introduced content, while the other modules contain knowledge learned in previous courses. Students therefore only need to focus on mastering the skills related to the new module to complete the project.

3.2.2 Establishment of the project baseline and objectives

The project baseline requires the hardware to include at least one button module, one LED module, one buzzer module, one photoelectric switch module, and one core system module. The software must implement basic functions such as intrusion detection and audible and visual alarms. The team must also complete project documentation and an on-site presentation. The outcome-focused baseline for this section is shown in Figure 7.

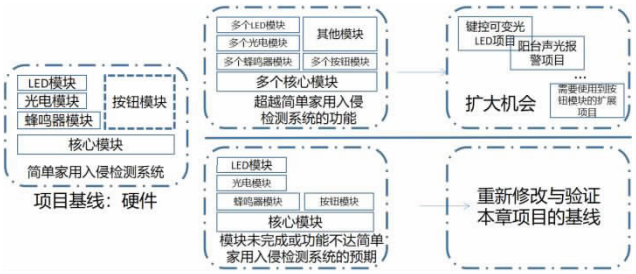


Figure 7 Outcome-focused project baseline

On the basis of meeting the baseline requirements, the project objectives encourage students to optimize system algorithms, extend functional modules such as mobile remote alarms, and improve hardware integration, ultimately forming individualized output outcomes.

3.2.3 Modular skills training

Training was conducted with loose-leaf teaching materials and an online learning system. The training focused on circuit design, driver development, and testing for the button module, supported by online resources such as video tutorials and technical documentation.



Figure 8 Resource components supporting modular skills training

Through on-site demonstrations, teachers trained students in core skills such as operating EDA design software, circuit soldering techniques, AI-enabled hardware design and implementation, and the use of AI tools for software development. They also provided individualized guidance on problems encountered during student operations to ensure that students mastered the key skills required for project implementation.

3.2.4 Contextualized project work

Students were divided by student number into six groups of three to four members each. Responsibilities for system design, hardware implementation, software development, documentation, and on-site presentation were assigned within each group, as shown in Table 2.

Table 2 Example of subtask assignments

Subtask	Specific content	AI use	Number of students	Collaborative?
Subtask: circuit implementation	Module soldering and testing	AI-enabled	2	No
Subtask: software development	Algorithms, code, flowcharts, testing	Primarily AI-assisted development	2	No
Subtask: system integration and debugging	Module installation, micro-wiring, integration, trial operation	AI-enabled	2	Yes
Subtask: project documentation	Module design diagram, module connection diagram, algorithm documentation, program flowchart, test documentation, user instructions, source code, presentation slides, team member assignment table	Primarily AI-assisted development	4	Yes

During project implementation, teachers provided focused guidance to two groups with weaker foundations and helped them solve problems in circuit soldering and code debugging. Three groups with stronger capabilities received extension tasks, such as adding a Wi-Fi module or a passive infrared detection module and optimizing alarm response speed.

3.2.5 Diversified outcome evaluation

Outcomes were evaluated through presentation-based demonstrations and three-dimensional assessment. Each group gave a presentation through a PPT explanation, equipment demonstration, and document display, as shown in Figure 9.

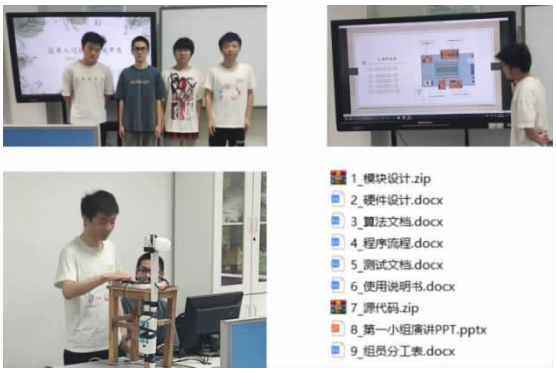


Figure 9 Student project presentation

Students evaluated one another as project teams. The teacher team conducted a comprehensive evaluation from the dimensions of technical complexity, application value, and practicality, while enterprise mentors remotely evaluated the final project outcomes. The three components were combined to produce the total score for each

group. All six groups met the project baseline, four groups extended their functions, and the outcomes of the remaining two groups showed considerable potential for market application.

3.2.6 Feedback and improvement

Student feedback questionnaires, project summary reports, and teaching reviews identified the following problems in practice: some students needed to improve their hardware soldering skills; the use of AI in software design was inconsistent; project documents produced with AI by some groups deviated from the actual project outcomes; and the difficulty gradient of extension tasks was not sufficiently reasonable. In response, subsequent teaching will optimize skills training, increase the hours of hardware soldering practice, add focused guidance on responsible AI use, provide project document templates, incorporate correction of AI-generated results, and refine the difficulty levels of extension tasks to meet the learning needs of students at different levels.

3.3 Practical effects

Tracking and data analysis of 105 students in three practice classes showed that applying the TTWO model produced significant effects.

First, output capability improved significantly. All students were able to independently complete the design and implementation of IoT node projects of low and medium difficulty, representing a significant improvement over the traditional teaching model. Among the three classes, the expanded project outcomes of four groups won awards in the college's innovation and entrepreneurship competition, and two projects successfully applied for utility model patents within three months after the course ended.

Second, skills were mastered more solidly. The pass rate for assessments of hardware circuit design and hardware module production exceeded 95%. The pass rate for core skills such as independently using AI for embedded software development exceeded 85%, a clear improvement over the traditional teaching model.

Third, overall competencies developed comprehensively. Questionnaire statistics showed that 86.8% of students believed project practice improved their teamwork ability, while 75.2% reported that their innovative thinking had been effectively exercised. The alignment with workplace requirements also improved significantly.

4 Conclusion

4.1 Research conclusions

This paper constructed an OBE-based TTWO project-based teaching model. Through a three-dimensional structure that combines OBE top-level control with TTWO bottom-level execution, it integrates outcome orientation, continuous improvement, and student-centeredness throughout the teaching process, effectively addressing the core problems of emphasizing process over results and projects over outputs in traditional project-based teaching. Practice shows that the model has four advantages: precise alignment between teaching content and workplace positions; teaching processes that meet students' differentiated needs; output outcomes that facilitate quality evaluation, feedback, and improvement; and closed-loop feedback that supports the stability and sustainability of teaching quality.

4.2 Limitations and prospects

The study was conducted only in the course Design and Implementation of IoT Nodes, and the quantitative evaluation of students' innovative ability in the evaluation system was not sufficiently precise. In the future, the TTWO model will be promoted in other core courses of the IoT major, the evaluation indicator system for innovative ability will be improved, and the objectivity and vocational orientation of evaluation results will be enhanced. Artificial intelligence will also be used to promote intelligent monitoring and precise improvement of the teaching process, providing more comprehensive theoretical support and practical reference for the reform of technical course teaching in higher vocational education.

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