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Teaching Reform and Practice of IoT Technology Course Promoted by Industry-Education Integration Based on the OBE Educational Philosophy

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Abstract: The existing Internet of Things technology course teaching generally has problems such as the disconnection between theory and practice, and the lack of students' hands-on ability and innovative thinking. To this end, this paper introduces the integration of industry and education based on the concept of outcome-based education (OBE), and solves the limitations of the traditional teaching model by deeply combining theoretical teaching with industry practice. This paper adopts the OBE education concept, combined with project-driven learning (PBL) and competition projects, and introduces the AIRIOT education platform to provide rich Internet of Things technology learning resources and practical environment, so as to promote students to master the application of Internet of Things technology in actual projects. In addition, through the course design that connects with industry needs, it ensures that students can acquire practical skills during their school years and improve their employment competitiveness. The integration of industry and education with the introduction of OBE education concepts has effectively improved students' practical ability and innovative thinking. Through refined teaching content arrangement and real-time feedback mechanism, students' hands-on ability, teamwork ability, interdisciplinary integration ability and problem-solving ability have been significantly enhanced, and the course evaluation indicators have also shown positive changes. The experimental results show that student D performs well in all innovation evaluation dimensions, with high scores for technology application innovation and solution uniqueness (10 and 9 points, respectively), and the innovation display score also reaches the full score of 10 points. The final overall innovation score is 9.67, showing that he has strong innovative thinking and technology application capabilities in the project.

1. Introduction

With the continuous development of modern educational concepts, students' performance in scientific experiments has received more and more attention, especially in interdisciplinary projects and teamwork. Scientific experiments are not only a place for the application of knowledge and skills but also an important platform for students to demonstrate their innovative thinking, problem-solving ability, cooperative spirit and technical mastery. Especially in the fields of Internet of Things, data analysis, interdisciplinary design, etc., students' comprehensive ability reflects their competitiveness in future practical work. Therefore, the process evaluation and outcome evaluation of scientific experiments have become the key to evaluating students' learning outcomes and abilities.

This study aims to explore the students' technical mastery, innovative performance, teamwork and other aspects of their performance in project experiments through detailed experimental data analysis. Through quantitative data indicators, including experimental progress, technical mastery, innovative scores, teamwork scores, etc., the students' performance is comprehensively evaluated and the impact of various factors on students' learning outcomes is analyzed. The ultimate goal of the study is to provide data support and theoretical basis for education reform, curriculum design and student ability assessment.

This paper first introduces the research background and purpose, and explains the importance of interdisciplinary cooperation and innovation in student projects. Then, the experimental design and evaluation methods are described in detail, including four dimensions: process evaluation, outcome evaluation, innovation evaluation, and teamwork evaluation. Subsequently, the paper presents the experimental data and analysis results, and explores the impact of teamwork, technological innovation, and interdisciplinary collaboration on project results in combination with specific student performance. Finally, the paper summarizes the research conclusions, points out the existing limitations, and puts forward prospects for future research.

2. Related Work

With the continuous development of the education field and the rapid advancement of technology, more and more innovative technologies have begun to be introduced into the education system to enhance the learning experience and teaching effectiveness. In particular, under the influence of Industry 4.0 and artificial intelligence, the education model is undergoing profound changes. Moraes and Kipper aimed to explore the application of Industry 4.0 technology in the field of education and its contribution to learning, especially its use at different stages of education. The study showed that Industry 4.0 technology supports the entire learning process, but has not yet been fully popularized, mainly concentrated in universities and manufacturing-related courses [1]. Elbanna and Armstrong explored the advantages of applying generative artificial intelligence technology, especially ChatGPT, to education. The study showed that ChatGPT can effectively automate daily tasks, enhance students' learning experience, and improve productivity and adaptive learning [2]. Cadiz et al. explored the impact of technological progress on higher education through a content bibliometric analysis of technology integration in Philippine higher education institutions. This study emphasizes that educational concepts should be aligned with the needs of Industrial Revolution 4.0, providing a practical blueprint for higher education to cope with the new normal and promote academic excellence and educational resilience [3]. Nguyen et al. explored how Problem-Based Learning (PBL) projects can support the realization of Sustainable Development Goals (SDGs) through higher education courses, teaching materials, and related assessments. The results showed that the school covered all 17 SDGs and 94 indicators, but some goals were not deeply integrated into the curriculum [4]. Based on an investigation of the current development of online education, Wang and Chen conducted an in-depth analysis of the problems existing in online education and proposed to deeply integrate the recently popular ChatGPT language model with online education to form a new intelligent learning model, covering intelligent tutoring, personalized learning material generation, and learning assessment [5]. Lee pointed out that medical educators need to pay attention to the rapid changes in technology and consider its impact on curriculum design, assessment strategies, and teaching methods, while also considering ethical issues and potential negative impacts [6]. Gupta et al. analyzed the current intelligent education technologies proposed by different scholars and emphasized the various limitations and challenges of existing intelligent education systems [7]. Onesi-Ozigagun pointed out that the application of AI has promoted personalized learning, provided customized learning paths based on students' performance data, and improved students' participation and academic performance. AI has also changed teaching methods, helping teachers simplify administrative tasks, providing real-time feedback, and promoting the development of critical thinking [8]. Dai et al. compared the differences in interaction between smart classrooms and traditional classrooms in project-based learning courses by analyzing the interaction between teachers and students in smart classrooms and traditional classrooms. The study found that smart classrooms differed significantly from traditional classrooms in teacher behavior, student behavior, technology application, and other interaction dimensions [9]. Allo M et al. described the implementation of OBE principles in the English Education degree program at the Christian University of Indonesia Toraja. The results showed that the implementation of OBE principles included: the curriculum reflected the commitment to education quality and met the needs of industry and society; detailed description of learning outcomes; and the use of active learning methods and technology integration [10]. Bhatti et al. explored the process of implementing an OBE framework in engineering education in Pakistan, focusing on the application of the Q-OBE system. The study aims to demonstrate how to improve evaluation efficiency through Q-OBE software, ensure compliance with the OBE implementation standards set by the Pakistan Engineering Council (PEC), and provide support for the accreditation of engineering education programs [11]. Although existing research has explored the potential of Industry 4.0 and artificial intelligence technologies in education, there are still bottlenecks such as insufficient popularization of technology, lack of in-depth research on implementation details, and failure to fully evaluate its long-term effects [12].

3. Method

3.1 Introduction and Application of AIRIOT Education Platform

3.1.1 AIRIOT education platform functions and resources

AIRIOT Education Platform is a comprehensive teaching platform based on Internet of Things (IoT) technology, which aims to provide students with comprehensive and systematic practice and learning resources. The platform mainly has the following functions and resources:

The AIRIOT education platform provides a virtual simulation environment for multiple IoT systems. Students can use the platform to simulate IoT-related technologies such as various sensors, wireless sensor networks (WSN), cloud computing, and big data technologies, and perform operations such as system integration, data transmission, and analysis and processing. This function provides students with a simulated IoT laboratory, allowing them to experience and understand the various modules of the IoT system in advance without actual hardware.

The platform has built-in rich course resources, including modules such as IoT basics, sensor networks, data acquisition and processing, and intelligent control. In addition, each course is equipped with detailed experimental tutorials and operation manuals to help students understand the practical application of theoretical knowledge. The platform also enhances students' practical operation capabilities by providing online programming, algorithm analysis, system design and other links.

3.1.2 How to improve students' practical ability through the platform

The AIRIOT education platform effectively improves students' IoT practical ability by providing an integrated learning and practice environment, which is mainly reflected in the following aspects:

(1) Improvement of practical operation ability

The platform uses the simulation environment and virtual laboratory functions to enable students to perform practical operations based on theoretical learning and master the configuration, debugging and use of IoT devices. Students can simulate the working process of the entire IoT system by combining with hardware devices, and gradually form an intuitive understanding of system design and optimization.

(2) Project-driven learning model

The platform provides students with a project-driven learning experience. In the process of completing specific projects, students not only learn how to design and implement IoT systems but also develop practical abilities such as project management, teamwork, problem analysis and problem solving. The project-driven learning model helps students gain in-depth skills and experience by starting from actual engineering problems.

(3) Cultivation of interdisciplinary capabilities

The application of IoT technology involves multiple disciplines, such as sensor technology, network communication, data analysis and processing, etc. Through the platform's multidisciplinary comprehensive resources, students can learn the application of these technologies on a comprehensive platform and cultivate interdisciplinary integration capabilities. For example, students not only need to learn how to use sensors to collect data but also need to understand how to transmit data through the network and apply cloud computing and big data technologies for analysis.

(4) Rapid feedback and self-learning

The platform provides students with a real-time feedback mechanism. When completing experimental tasks, students can immediately view experimental results and system performance analysis, quickly identify problems and make corrections. Through this instant feedback, students can deepen their understanding of the working principles of the IoT system and cultivate the ability to learn and solve problems independently.

3.2 Teaching Model Combining Project-Driven and Competition Projects

3.2.1 Implementation strategies of project-driven teaching

Project-Based Learning (PBL) is a teaching method centered on practical projects, which aims to improve students' comprehensive abilities through their exploration and cooperation in solving practical problems. In the Internet of Things technology course, project-driven teaching can not only expose students to real application scenarios but also help students consolidate theoretical knowledge and cultivate hands-on ability, innovation ability and teamwork spirit. The strategies for implementing this teaching model include the following aspects:

Project topics are closely integrated with course content: Project topics in the course should be closely related to the core content of IoT technology, such as sensor networks, data collection and analysis, intelligent control systems, etc. These projects should not only be challenging but also consistent with current industry needs to ensure that students can learn skills related to future career development in project practice.

Phased implementation and teamwork: Projects are usually divided into multiple phases, including demand analysis, solution design, system integration, testing and optimization, etc. The completion of each phase requires students to work together within the team, combining their professional backgrounds and expertise to jointly achieve project goals. Teachers provide guidance at each stage to ensure that students can solve problems in a timely manner during the project and adjust the project direction according to actual progress.

Interdisciplinary integration and practical application: Project-driven teaching encourages students to integrate knowledge across disciplines, especially since IoT technology involves multiple disciplines, such as electronics, computer science, and communications technology. Students need to apply knowledge from various disciplines to practical projects to improve their comprehensive problem-solving abilities. For example, when designing a smart home system, students need to use knowledge such as sensors, embedded programming, data processing and analysis to simulate and implement system functions.

Real-time feedback and evaluation mechanism: Project-driven teaching emphasizes real-time feedback and evaluation to help students continuously optimize project results. Teachers regularly check project progress, provide technical support and feedback, and guide students to solve problems during the project. At the same time, project evaluation not only focuses on the final results but also includes students' performance during the project, such as problem analysis ability, innovative thinking, teamwork and other aspects.

3.2.2 Organization and participation in competitions such as iCAN and the Electromechanical Product Innovation Competition

Competitions such as iCAN (International College Student Innovation and Entrepreneurship Competition) and the Electromechanical Product Innovation Competition are important components of project-driven teaching. These competitions can not only inspire students' enthusiasm for innovation but also help students apply classroom knowledge to actual projects, improving their hands-on skills and their ability to solve practical problems.

Competition organization and preparation: Schools usually organize student teams according to the requirements of the competition and encourage interdisciplinary cooperation. The competition topics keep up with the forefront of science and technology and are closely related to IoT technology. They are both challenging and can help students master the latest technology applications. During the competition preparation process, teachers and corporate mentors participate together to provide technical guidance and resource support to ensure that students can complete high-quality projects within a limited time.

Combination of theory and practice during the competition: Competition projects usually require students to combine their knowledge to solve practical problems. Taking the iCAN competition as an example, students may need to design a complete IoT solution, such as smart home, smart agricultural monitoring, etc. In this process, students will use the design principles of the IoT system, the construction of wireless sensor networks, data processing and analysis technologies to form a complete solution. Every link of the competition requires students to combine theoretical knowledge with practical applications to form a profound practical experience.

Project design that matches industry needs: The topics of competition projects are usually based on the latest industry needs, such as smart cities, smart manufacturing, environmental monitoring, etc. By participating in these competitions, students can not only be exposed to the current application of IoT technology but also understand industry development trends and corporate needs. Such design not only exercises students' innovative thinking but also allows students to have a clearer understanding of the future job market.

4. Results and Discussion

4.1 Experimental Equipment and Platform

Hardware equipment: sensor modules, wireless sensor network (WSN) devices, IoT gateways, embedded development boards, computers and other devices that support IoT experiments.

Software platform: AIRIOT education platform, LabVIEW, Arduino IDE, MATLAB and other development and simulation tools.

Competition platform: iCAN platform, electromechanical product innovation competition platform.

4.2 Experimental Evaluation and Assessment

Process evaluation: Evaluation is conducted by observing students' performance in the experiment, teamwork, project progress and experimental records.

Table 1. Process evaluation

Student Name	Experiment Task Name	Experiment Progress (%)	Teamwork Performance	Experiment Record Quality	Technical Mastery
Student A	IoT System Design and Implementation	90%	Excellent	Good	Fair
Student B	IoT Application Scenario Simulation	80%	Good	Excellent	Good
Student C	Competition Project Design and Development	70%	Average	Fair	Fair
Student D	Interdisciplinary Project Implementation	85%	Good	Excellent	Good
Student E	Data Analysis and Optimization	95%	Excellent	Good	Excellent

Student E performs well in terms of experimental progress, teamwork performance and technical mastery. His experimental progress reaches 95%, his teamwork and technical mastery are both rated "excellent", and the quality of his experimental records is "good". This shows that student E can complete the task efficiently and has strong technical mastery, and performs well in teamwork. Student A's experimental progress is 90%, his teamwork performance is "excellent", and his technical mastery is "good", showing his efficient advancement and teamwork ability in the project. Although his technical mastery is lacking, he is still able to complete the task well. Student D's experimental progress is 85%, his teamwork performance is "good", and his technical mastery is "good", which shows that he can steadily advance the project and play a certain role in the team, but there is still room for improvement in technical mastery and cooperation performance. Student B's experimental progress is 80%, his performance in teamwork is "good", the quality of experimental records is "excellent", and his technical mastery is "good". Although his technical mastery and record quality are good, his experimental progress and teamwork performance are slightly worse than other students. Student C's experimental progress is 70%, as shown in Table 1.

Outcome evaluation: Evaluating students' learning outcomes based on their final project results, competition results, and project presentations.

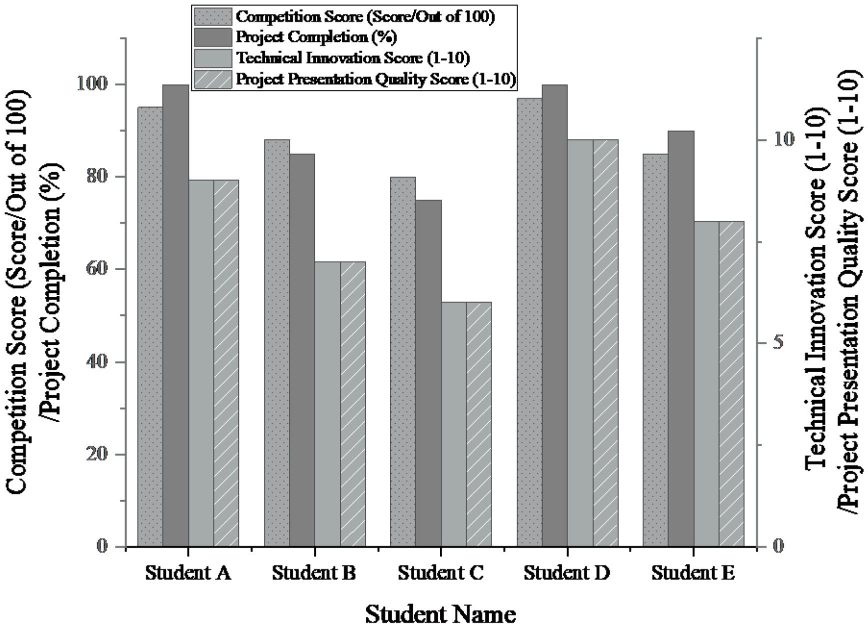

Figure 1. Evaluation of the results

According to the analysis of the experimental data in Figure 1, the performance of students in the projects varies significantly, which is reflected in the project completion, technical innovation, project presentation quality and competition results. Students A and D perform well in all indicators, especially in technical innovation and project presentation quality, with high scores (9 and 10 points, respectively), and achieved close to full marks in the competition (95 and 97 points), showing their high level of technical ability and innovation. In contrast, students B and E lack in project completion and presentation quality. Although their competition results are good, the depth and technical innovation of their presentations are slightly insufficient. Student C performs relatively mediocre in all aspects, with low scores for project completion and innovation, and his competition results do not reach the ideal level, indicating that he may have certain difficulties in teamwork and project implementation. Overall, students D and A perform the best, especially in technical innovation and project presentation, while students B, E and C need to strengthen their relevant skills and participation to improve the overall project performance.

Innovation evaluation: Evaluating students based on their innovative performance, technical applications and unique solutions in the competition projects.

Student D performs well in all innovation evaluation dimensions, with high scores for technology application innovation and solution uniqueness (10 and 9 points, respectively), and the innovation display score also reaches the full score of 10 points. The final overall innovation score is 9.67, showing that he has strong innovative thinking and technology application capabilities in the project. Student A's innovation score is relatively high (8.67), especially in technology application innovation and innovation display, but the solution uniqueness is relatively ordinary. Student E performs relatively well, with an innovation score of 7.67, showing a certain degree of technical innovation, but the uniqueness of his solution is slightly insufficient. Student B and Student C score lower in innovation (6.67 and 5.67, respectively), especially in terms of solution uniqueness and technical application innovation, indicating that their projects still have a lot of room for improvement in terms of innovation, as shown in Figure 2.

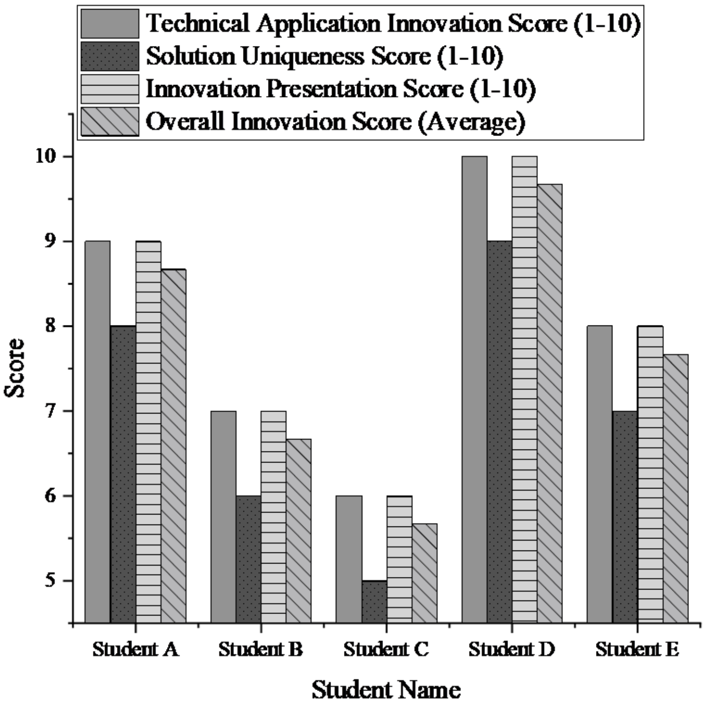

Figure 2. Innovation evaluation

Teamwork evaluation: Evaluating students' teamwork spirit and leadership ability in the team, especially in interdisciplinary cooperation.

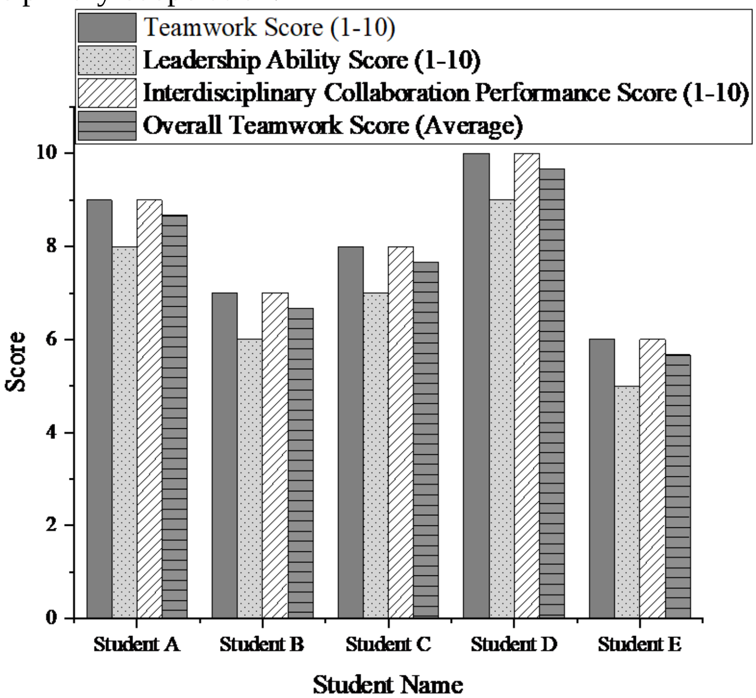

Figure 3. Teamwork evaluation

According to the data analysis of the teamwork evaluation in Figure 3, there are significant differences among students in terms of teamwork, leadership, and interdisciplinary cooperation. Student D performs well in all teamwork dimensions, and receives high scores in teamwork, leadership, and interdisciplinary cooperation (10, 9, and 10 points, respectively), making his overall teamwork score reach 9.67, showing that his leadership and interdisciplinary cooperation abilities in the team are very outstanding. Student A also performs well, with an overall teamwork score of 8.67, especially in teamwork and interdisciplinary cooperation, but his leadership ability is slightly inferior to that of student D. Student C's teamwork score is relatively balanced (7.67), with certain advantages in teamwork and interdisciplinary cooperation, but relatively weak leadership. Student B scores lower, with an overall teamwork score of 6.67, and his leadership and interdisciplinary cooperation performance are poor, indicating that his role in teamwork is relatively limited. Student E had the lowest teamwork score (5.67), showing weak teamwork, leadership and interdisciplinary cooperation abilities, indicating that his role in the team is relatively small.

5. Conclusion

This study comprehensively evaluates the students' performance and growth in the project by analyzing the experimental data of students in interdisciplinary projects, combining process evaluation, outcome evaluation, innovation evaluation and teamwork evaluation. The results show that the completion of students' projects is closely related to factors such as experimental progress, technical mastery, and teamwork, especially the performance in interdisciplinary cooperation has a significant impact on project results. Teamwork and technological innovation are important factors affecting students' final results. Good teamwork and innovative solutions can significantly improve the quality of project completion and competition results. Although some students perform well in technology application and innovation display, many students still encounter difficulties in the project, especially in interdisciplinary cooperation and the development of innovative solutions. The study reveals the students' innovative potential in practical applications and their collaborative ability in teamwork, and emphasizes the importance of cultivating students' interdisciplinary thinking and innovation ability. However, this study also has certain limitations. First, the sample size is small, and the data source is mainly concentrated on students in a specific field, lacking a broader interdisciplinary background. In addition, the experimental evaluation mainly relies on quantitative scoring, which may not fully capture the details of students' performance in the innovation process. Future research can expand the sample range, increase the participation of students from different disciplinary backgrounds, and further explore the intrinsic relationship between teamwork and innovation ability.

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