Research on Integrated Training and Hybrid Teaching of Industrial Robot Technology Based on Virtual Simulation

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Abstract. In response to the current problems in the comprehensive training and teaching of industrial robot technology, virtual simulation technology is used to integrate the concept of hybrid teaching, explore a new teaching mode that combines virtual and real, and achieve the combination of classroom teaching and engineering practice. By optimizing the course outline and content structure system, based on PQArt software, theoretical knowledge, operational points, skill training, and professional literacy are integrated into practical training to deepen understanding. A virtual simulation training platform is established, and virtual simulation is combined with on-site practice to carry out mixed online and offline training. The practical results indicate that using this teaching mode can improve classroom teaching efficiency, stimulate students' learning enthusiasm, and cultivate their ability to learn and think independently.

Keywords: Industrial robot · virtual simulation · blended teaching · engineering practical training

1 Introduction

With the promotion of the national strategy for intelligent manufacturing and the demand for talent in the market, industrial robot technology training has become an essential part of engineering training in domestic undergraduate universities [1]. The cultivation of talents in the field of robotics is beneficial for promoting the development of the intelligent manufacturing industry, and practical teaching is the key to cultivating the professional abilities of robotics students [2]. However, for a long time, there have been problems such as insufficient opportunities for practical operation and insufficient training for innovative abilities in the practical teaching process of robotics [3]. This is reflected in the following aspects: Insufficient hardware investment and limited operating time. This makes it difficult for students to deeply and comprehensively master robot operations, resulting in poor practical training results [4]. Beginners are not familiar with equipment, and practical safety risks are high. Single learning methods and limited learning resources. Most students still rely on course materials and library related books, lacking effective and convenient ways to learn robotics technology [5]. This issue also

© The Author(s) 2024
F. Huang et al. (Eds.): ICAIE 2023, AHCS 15, pp. 250–257, 2024.
https://doi.org/10.2991/978-94-6463-242-2_31

restricts the learning of students' professional skills and the cultivation of their innovative abilities.

Building a visual simulation platform for robots based on virtual simulation technology can provide students with an interactive real-time simulation foundation and help them complete courses, skill competitions, and projects related to robots at the lowest cost [6]. But currently, most of the supporting simulation software can only support the ontology modeling and simulation of their own robots, with poor universality and secondary development ability, which cannot better stimulate students' creativity and stimulate their learning enthusiasm. This article is based on the virtual simulation training platform of PQArt software, exploring a new teaching mode of combining virtual and real, conducting mixed teaching research that integrates online and offline, and actively exploring new modes of industrial robot talent cultivation. This will help promote the improvement of students' abilities and enhance their competitiveness in employment.

2 Virtual Simulation Teaching Design Based on PQArt Software

PQArt is an industrial robot offline programming software launched by Beijing Huahang Weishi Robot Technology Co., Ltd. Software is widely used in fields such as polishing, deburring, welding, laser cutting, CNC machining, etc. It is compatible with multiple brands of robots, has strong practicality, can simulate real operating steps, has high safety, is easy to achieve personalized teaching goals, and has good fun. Based on PQArt software, a virtual simulation and training teaching system for industrial robots can be established, which can be customized according to the teaching objectives and content of Nanchang Engineering College. Free definition of various devices in the production line, compatible with various brands of robots, and students can perform virtual operations anytime and anywhere, freely practicing repeatedly. Teachers can upload teaching resources and design hierarchical and multitasking practical teaching projects. Students can choose their own learning content to meet personalized learning needs. By developing interesting human-computer interactions, students' interest in learning is stimulated, and their ability to explore new knowledge and innovate through modern information technology is cultivated.

As an offline programming software for robots, PQArt's work process is divided into five steps: scene construction, trajectory design, simulation, post processing, and real machine operation. The simulation process of the training project is shown in Fig. 1. Trajectory design can be divided into four ways: Penerating trajectories from 3D model points, lines, and surfaces, suitable for deburring, cutting, welding, and other processes. Projection of curves onto surfaces to generate trajectories, suitable for polishing and other processes generate trajectory by adding surfaces to curves, suitable for spraying, intelligent handling, grasping and other processes. The software also supports importing external trajectories and binding them with machined parts.

Then there is process simulation. According to the robot's kinematics and dynamics knowledge, a continuous robot posture is generated. At the same time, the collision check module is started to check whether there are ambiguity points and whether there will be interference during the robot's working process. The post module generates the corresponding robot post code based on the currently selected robot manufacturer and

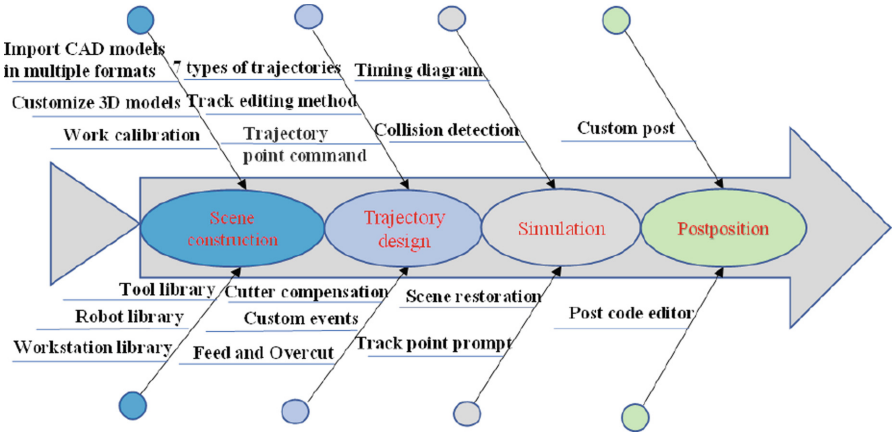


Fig. 1. Simulation Process of Training Projects

model. Finally, there is real machine debugging, which transfers the post code to the robot body to debug the actual working situation of the robot.

3 Implementation of Blended Learning Mode Based on Virtual Simulation

3.1 Design of Robot Virtual Reality Training Content

Relying on the existing virtual simulation training platform of the training center, we have tendered and customized industrial robot virtual simulation training resources. The basic requirement of the construction is that flexible customization and secondary development can be carried out according to the actual application needs of customers, while meeting the requirements of progressiveness, openness, stability and security. The industrial robot virtual simulation training teaching system has a complete online learning process and teaching management functions. Teachers can independently upload, modify, create, and integrate system resources, and can also engage in online teacher-student interaction and communication, track students' learning progress, and evaluate the training results. The layout of the training room and the virtual effect diagram are shown in Fig. 2.

The design of industrial robot training content follows the student-centered approach, with practicality and local talent needs as the basic principles. In accordance with the requirements of project-based teaching methods, multiple training projects are constructed, including robot basic principles training projects, robot disassembly and assembly training projects, robot manual manipulation and coordinate system setting training projects, robot simple motion trajectory programming projects Comprehensive projects such as robot drawing and robot handling and stacking. The project design starts from the basic principles and structure of robots, then to basic operation and programming training, and finally to comprehensive design training. Through this hierarchical and gradual learning mode, a complete industrial robot training system is constructed.

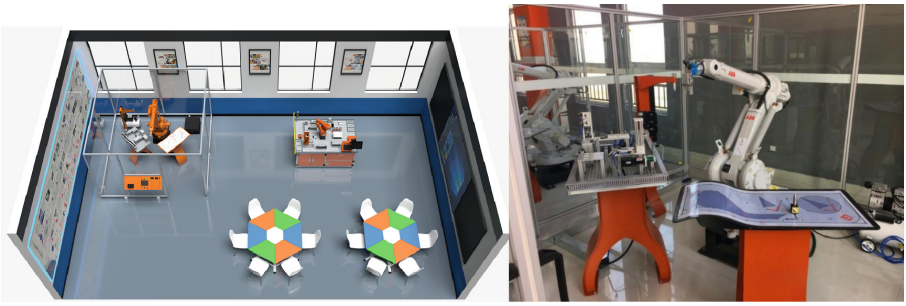
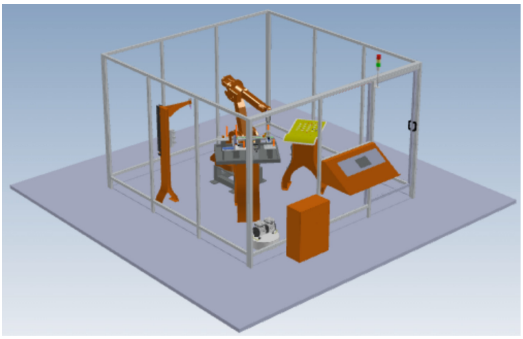
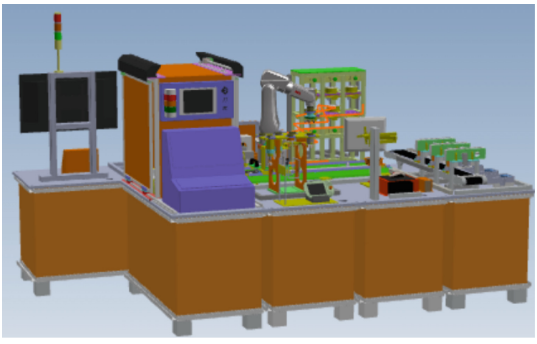


Fig. 2. Layout and virtual effect of the training room site

The industrial robot virtual simulation training project is shown in Fig. 3, and the system can also record the access situation of individual project students, facilitating the analysis of students' learning behavior and preferences using data, and better improving teaching content.



a. Industrial robot basic teaching workstation



b. Intelligent Manufacturing Comprehensive Platform

Fig. 3. Industrial robot virtual simulation training project

3.2 Implementation of Blended Learning Teaching Mode

In order to solve the problems of limited course hours, multiple knowledge points, and useless learning, a diversified and three-dimensional teaching model combining online and offline is established. Learning includes online pre class preview, offline in class teaching, and various ways of post class review. The implementation idea of practical training teaching mode based on virtual simulation blended learning is shown in Fig. 4. Online pre class preview, teachers send training content and requirements to students through teaching systems or email, and students select corresponding project resources for learning on the training system. Students are required to familiarize themselves with the basic knowledge of industrial robots before class, complete virtual simulation training operations for specific projects, and have an understanding of the entire operation process. Students can use the "Course Exchange" section to interact online with teachers when encountering problems during practical training, and teachers can provide guidance and answers.

Offline classroom teaching involves visiting a real industrial robot training room. Teachers first check the overall situation of students' pre class previews, and do not explain too much about the basic knowledge that students can master before class. They focus on teaching key and difficult knowledge points, while guiding students to actively discuss and interact during the training. Next, the teacher will provide a physical explanation and demonstration, which can be operated by students. The teacher will guide and explain the process, observe the students' proficiency in actual operation, and then group together to complete basic training projects such as manual operation of industrial robots, setting of tool coordinate systems, and setting of workpiece coordinate systems. Finally, have students group together to complete practical training tasks, such as robot drawing training, which does not limit the drawing of graphics. Each group will discuss and design, write and debug programs, and complete the robot's motion trajectory.

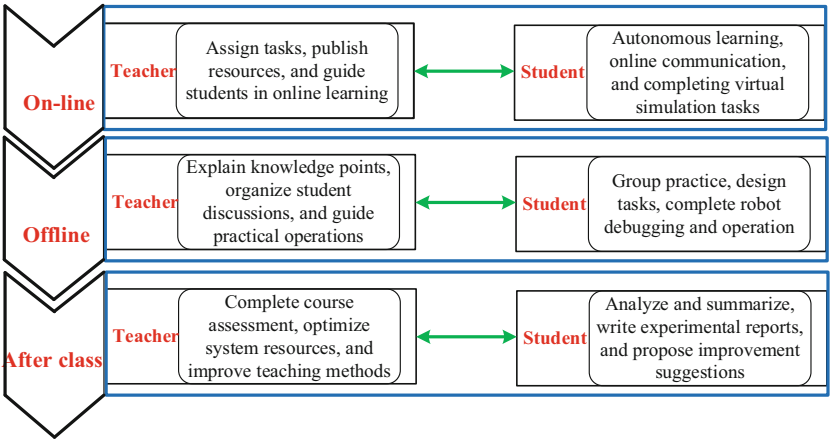


Fig. 4. Schematic diagram of practical training teaching mode based on blended learning

Table 1. Distribution of assessment scores for achieving course objectives

Graduation requirements	Assessment method and proportion of results (%)			Score ratio (%)
	Process management	Achievement assessment	Training Report	
Design/develop solutions	5	20	10	35
Using modern tools	0	20	10	30
Individuals and teams	10	10		20
Project management	5		10	15
Total	20	50	30	100

After class analysis and summary every day, students write training reports based on the training process and results, reflect and summarize the problems that exist during the training process, and propose improvement suggestions. Students who have spare energy and are interested in learning can further delve into the virtual simulation training system and complete higher-level training projects. Provide feedback and suggestions to students, adjust training content and teaching methods, optimize system resources, and improve teaching methods. The course introduces a dynamic process evaluation mechanism, which assesses students' learning effectiveness through various methods such as submitting online projects and student mutual evaluation projects. The new assessment method has increased the proportion of daily performance and comprehensive practical ability, improved students' learning enthusiasm and innovative initiative in practice, and avoided the drawbacks of students' concentrated assault at the end of the term. The corresponding relationship between course teaching objectives and assessment methods is shown in Table 1.

3.3 Implementation Effect of Teaching Mode

1. From the perspective of classroom teaching process and daily performance, although most students have never been exposed to real industrial robots before, they are mostly easy to learn and have a low error rate in actual operation. The teaching organization of offline classrooms is compact and the atmosphere is lively, with a high proportion of students completing tasks according to requirements.
2. From the perspective of process assessment, training reports, and feedback, students unanimously agree on this online and offline virtual simulation hybrid teaching mode. It is generally believed that online virtual simulation operation training is very helpful for subsequent practical operations. Virtual simulation, a realistic teaching method and rich learning resources, can greatly stimulate their learning enthusiasm.
3. From the perspective of improving students' innovation and collaboration abilities, open virtual simulation teaching resources and random practical training processes

can effectively exercise students' innovation ability and cultivate their ability to actively think and solve problems. In the process of practical training and teaching, guide students to group, collaborate, and work together to complete a task, promote mutual communication, and cultivate team collaboration ability.

4 Conclusion

By combining the advantages of virtual simulation and hybrid teaching, we aim to carry out a combination of online and offline industrial robot training and teaching. Through the virtual simulation training and teaching system, students can explore learning resources, develop learning plans, and complete autonomous learning, making themselves the subject of learning; At the same time, teachers use classroom teaching to strengthen interaction with students and guide them to complete the verification process from theory to practice, and from simulation to practice. The results show that the teaching mode based on virtual simulation blended learning has been recognized and praised by students, which can effectively improve students' learning interest, cultivate students' initiative innovation ability, hands-on practice ability and team cooperation ability.

Acknowledgements. This work was financially supported by the Jiangxi Province Higher Education Teaching Reform Research Project (JXJG-21-18-7), Jiangxi Province Higher Education Teaching Reform Research Project (JXJG-22-18-12), and Jiangxi Province Higher Education Teaching Reform Research Project (JXJG-22-18-6).

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