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Teaching of Industrial Robot Spot Welding Project Based on Work Process Orientation

Xiang Xu

Tongji University, Shanghai, 200092, China

Abstract: *The work process oriented curriculum originated in Germany and is a typical curriculum model of the integration of theory and practice with work and learning. Based on the concept of work process orientation, this article takes a complete industrial robot spot welding debugging application project as an example, selects a knowledge point that covers the operation and programming of industrial robots, and conducts teaching practice analysis and discussion according to the six basic working processes of information, planning, decision-making, implementation, inspection, and evaluation, with a view to providing reference for the teaching of industrial robot related courses.*

Keywords: *Work Process Oriented; Spot Welding Application; Industrial Robot*

1. Introduction

"Work process oriented" is an educational method based on actual work scenarios, which has been applied as early as in Germany [1]. The main purpose is to enable students to better apply their knowledge in practical work. "Operation and Programming of Industrial Robots" is a core course for industrial robot technology application majors, involving theoretical, practical, and comprehensive aspects, requiring a certain programming foundation. However, due to the poor foundation of students in secondary vocational schools, it is difficult to understand programming principles and programming thinking. If only classroom instruction is used for teaching, it is difficult to improve students' learning enthusiasm. Therefore, the author takes the teaching project of "spot welding and debugging of industrial robots" as an example to explore and study the teaching practice of the course based on the work process, in order to form the post awareness and improve the learning initiative of students in their learning.

2. Teaching Case of Industrial Robot Spot Welding Debugging Based on Work Process Orientation

After investigation, the author found that welding applications in modern chemical plants inevitably require manual participation, which is limited to the uncertainty of product stampings, the position of welding guns in welding applications, and the interference of surrounding equipment. Manual participation is often required.*[2]* With the improvement of technology, welding applications have gradually transitioned from basic arc welding and spot welding to a large number of laser welding with higher accuracy, Therefore, the migration of spot welding applications is more extensive. This article can use industrial robots to conduct spot welding examples, allowing students to learn and use flexibly, drawing inferences from one example, and thinking more about themselves. Instead of being a repetitive worker that can be replaced at any time, they are technical personnel who can solve production problems in actual work.

This teaching is aimed at Grade 2 students of secondary vocational school who have learned and mastered the basic knowledge of industrial robots, mechanical drawing recognition, and electrical component recognition before entering the course. Before proceeding with the example task, I have passed the preliminary learning content of this course, and learned the basic operation of industrial robots, I/O communication, PLC basic programming, routine data and programming content, and basic knowledge of manual welding. I have a certain theoretical knowledge foundation, and am familiar with relevant electrical professional operation specifications and process requirements. I have also been exposed to relatively simple practical courses for entry-level case applications, such as handling. On this basis, introducing welding cases with a slightly higher level of difficulty is challenging for students, but also has operability, making it easier to stimulate students' interest and enthusiasm in learning.*[3]*

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2.1. Teaching objectives

2.1.1. Knowledge objectives

Proficient in calling industrial robot routines; Read the motion commands, I/O control commands, and logic control commands commonly used in welding, especially spot welding applications; Can speak the skills of spot welding program writing.

2.1.2. Skill objectives

Master the assembly and adjustment of industrial robot welding gun; Master the import operation of program modules; Able to program edit commands such as SpotL/SpotJ, welding I/O, etc; Ability to write robot spot welding programs by oneself; Ability to use offline software such as RoboMaster and RobotStudio for offline programming.

2.1.3. Quality objectives

Cultivate students' rigorous work attitude; Cultivate students' collective consciousness and team spirit; Cultivate students' ability to explore independently.

2.2. Teaching content

According to the actual welding project execution process of an automotive equipment manufacturing company, design related teaching content, and conduct quantitative evaluation based on the spot welding quality of the workpiece and the completion of the welding spot. Qualitative evaluation is conducted on the learning effect and feedback of students.*[4]* According to enterprise research and understanding, the main work of industrial robot engineers is to calibrate the parameters of robots, workpieces, fixtures, welding guns, and other parameters according to the process parameters and technical standards provided by Party A, and compile spot welding procedures to achieve accurate robot spotting, ensure welding quality, and delivery. The teaching requirement is to design based on the actual production needs of actual enterprise research, effectively meet the actual work scenarios of the enterprise, and comply with the cognitive rules of students. Based on the actual work needs of the enterprise, the design teaching content includes robot motion trajectory selection, program framework diagram confirmation, program design and writing, manual verification, virtual simulation verification, motion trajectory teaching, and welding motion parameter teaching.

2.3. Teaching methods

This teaching case adopts a project based approach, emphasizing a comprehensive teaching model of "student centered" and "teacher led". Students can learn about career goals, work processes, and knowledge through information, planning, decision-making, implementation, inspection, and evaluation during the learning process through simulated real industrial robot operation scenarios.

2.4. Teaching implementation

The course of automatic spot welding and debugging for industrial robots has a total of 10 class hours. The teaching process based on the working process should highlight the student's main body, with the assistance of teachers. At the same time, it should run through the six steps of consultation, decision-making, planning, implementation, inspection, and evaluation.*[5]*

2.4.1. Information

This link will simulate a real enterprise environment in which teachers will play multiple roles such as project management and technical chief engineer.

First of all, the teacher will introduce the learning situation of "spot welding and debugging of industrial robots" to students: A large automotive manufacturer currently has a new model side panel workstation that requires automatic spot welding of the side panel at a beat of 60JPH. Our company, as an integrator enterprise, undertakes this project, and ultimately completes the acceptance after meeting the beat requirements and passing the weld quality inspection.

Secondly, the teacher will introduce the main content of this task: industrial robots grasp the automatic welding gun and move it to the designated position of the corresponding workpiece for spot welding operations. The specific tasks are: 1. Select a reasonable robot motion trajectory 2. Confirm

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the program framework according to the motion trajectory 3. Write an action path program 4. Verify the action path, and manually debug it 5. Verify the motion trajectory through virtual simulation 6. Perform practical teaching of the motion trajectory 7. Perform practical teaching of welding motion parameters. Finally, submit the motion trajectory, program block diagram, code, and welding parameters.

The purpose of information is for students to have a basic understanding of the working process of the entire industrial robot spot welding workstation, and to carry out theoretical learning with the purpose of work, so as to achieve the purpose of learning and using it as it is.

2.4.2. Planning and decision-making

Using the knowledge gathered during the information session, students develop task plans, list equipment, tools required, and implementation steps. Then, the team's task plans are summarized and displayed. The teacher evaluates the feasibility of each team's plan, clarifies the workflow, and highlights key issues in the task process. Finally, it is concluded that the automatic spot welding of industrial robots is divided into nine implementation steps: (1) Creating a coordinate system (2) Programming using commands such as LIN, PTP, and I/O (3) Obtaining PLC start signals and returning to position (4) Setting related parameters (5) Determining the coordinate system (6) Teaching each coordinate point of the motion program code (7) Using the PD/PS software to simulate and verify the trajectory (8) Teaching industrial robot practical welding (9) Closing the industrial robot.

During the planning and decision-making process, students can sort out the relevant theoretical knowledge they have learned before. At the same time, group discussions and presentations can enhance their sense of teamwork. After division of labor, it can make students more intuitive about the responsibilities they need to assume in their careers, and promote the development of professional literacy.

2.4.3. Implementation and inspection

According to the previously developed task steps, the actual installation, debugging, and inspection exercises will be carried out. During the entire process, the teacher will tour back and forth between various groups to guide students in practical operations, complete equipment installation and setup, promptly point out students' non-standard operations, control the work process, and ensure that students can complete the tasks within the specified course time.

Students carry out project implementation and complete specific project tasks according to the established work plan. During the entire implementation process, after each step is completed, the team needs to inspect the content to ensure that it can proceed smoothly to the next step, and that all work tasks are completed and suitable for overall inspection, so that the entire robot can operate. The workflow for implementing specific tasks of the project includes:

(1) Plan robot motion trajectory. (2) Confirm the program framework diagram. (3) Write trajectory program based on motion trajectory and program framework diagram. Team work within the group to program spot welding applications through previous industrial robot operation routes and program diagrams. (4) All teaching points in the teaching motion trajectory. (5) Verify the motion trajectory through virtual simulation, and the simulation effect is shown in Figure 1. (6) Practical operation and teaching of industrial robot motion trajectory and welding motion parameters.

Figure 1: Simulation of Industrial Robot Automatic Spot Welding

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2.5. Evaluation

After the teaching of the course is completed, the teacher will distribute a teaching evaluation form, and each group will conduct self-evaluation and mutual evaluation. The teacher will fill in the evaluation based on the performance of students in the classroom and the quality of the final task results, and send the final result video to the enterprise mentor, who will conduct professional grading. At the same time, with reference to the form of enterprise recognition meetings, students with outstanding performance in the project will be recognized and commended.

3. Reflections on the Teaching Practice of Courses Based on Work Process Orientation

According to the previous survey of schools, it is concluded that there are still many shortcomings in the existing curriculum teaching, leading to unsatisfactory teaching results. The following specific analysis is made on the reasons:

3.1. Improve students' learning initiative

"Operation and Programming of Industrial Robots" is a course that includes boring teaching content such as programming and offline simulation. However, it is difficult to stimulate students' learning enthusiasm if only classroom teaching is used. Adopting more realistic and specific work tasks in actual work as teaching content can better improve students' learning initiative. In this way, students can not only gain an in-depth understanding of real future work scenarios and actual work processes, but also gradually accumulate work experience and practical skills in practice [2]. This teaching method not only makes the learning process more interesting, but also better cultivates students' job awareness and improves their adaptability and competitiveness in their future career.

3.2. Improve the comprehensive ability of the "double qualified" teaching team

Teachers play a crucial role in the teaching process, requiring high-level professional knowledge and strong skills to meet the requirements of "dual qualification" quality.[3] However, due to the lack of participation experience in practical work with enterprises, it is difficult for teachers to develop teaching projects that are more in line with actual production needs. In order to improve the comprehensive ability of the teaching staff, a series of measures should be taken, such as closely integrating with enterprise planning arrangements, regularly releasing part-time teacher recruitment information, establishing a part-time teacher subsidy system, and establishing a part-time teacher database.[4] These measures should foster the selection and introduction of professional leaders with strong technical capabilities and significant influence from industry enterprises, and gradually establish a "dual qualification structure" teaching team with close ties to enterprises, stable scale, personnel flow, and a combination of full-time and part-time positions.

3.3. Optimization of evaluation system

The practical teaching of the "work process oriented" course is a brand new teaching mode, which closely combines the teaching process with practical work through a high degree of integration of theory and practice. Therefore, it is necessary to explore a practical teaching quality evaluation system that conforms to the laws of vocational education and is easy to operate. In practical teaching, evaluation should pay more attention to students' actual abilities and work skills, such as supervision and guidance of students' work processes, comprehensive evaluation of practical projects, etc. [5]. This evaluation method can better reflect the performance and achievements of students in the practical process, and help students better adapt to future work needs.

4. Conclusion

The work process oriented course is a comprehensive list of typical work tasks, aimed at transforming the teaching content of the industrial robot operation and programming course into tasks to improve the practicality of teaching. This teaching method focuses on tasks, trains students' professional skills and theoretical knowledge, and designs the required knowledge and skills into multiple tasks based on the actual work process. Students gain a sense of achievement by completing each task, and are able to actively learn and improve practical skills. In the teaching process, the main

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role of students and the leading role of teachers should be fully played, and knowledge should be imparted by guiding students to complete tasks. Teaching follows the complete work model of "information decision-making planning implementation inspection evaluation" to achieve tasks, thereby enabling students to turn to work process knowledge. Practical teaching has proven that adopting a process oriented curriculum development model has clear tasks, high learning initiative, and good teaching results.

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