# Application and Practice of "Integration of Theory-Virtuality-Reality" Teaching Based on Equipment Maintenance Welding

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**Abstract:** Focusing on the mastery of equipment maintenance welding skills, a task-driven "integration of Theory-Virtuality-Reality" teaching mode is constructed and applied in classroom reform practice. Starting from the cultivation of equipment maintenance welding skilled talents, taking the professional course of welding flat angle welding training as an example, aimed at the characteristics of skill training, combined with virtual welding teaching methods, integrating task-driven teaching methods and a combination of theory and practice teaching methods, a task-driven "integration of Theory-Virtuality-Reality" teaching mode based on equipment maintenance welding has been proposed, and this teaching mode allows students to correctly analyze the welding operation process through case studies, practice welding operation techniques through virtual simulation, and finally use practical operation assessment to verify the welding quality effect. Through this teaching mode, students can achieve a good grasp of welding training subjects.

**Keywords:** Equipment maintenance welding; integration of theory-virtuality-reality; task-driven teaching; application and practice

## 1. Introduction

The equipment maintenance and welding techniques mainly refer to the fault maintenance welding methods both for combat readiness and in emergency situations, with characteristics of quickly and accurately carrying out welding and repair operations in any harsh environment or complex welding position, thereby ensuring the long-term standby and good operation of equipment during wartime. Therefore, the application of welding technology in equipment maintenance support and battlefield emergency repair is becoming increasingly prominent; especially when the cultivation of welding skilled talents is currently a key point that needs to be strengthened. It is necessary to reasonably select and establish a maintenance welding support professional team with clear professional division of labor, equal emphasis on theory and skills, and rigorous technical attitude, to ensure the ability to quickly respond, efficiently maintain, and urgently repair in emergency situations[1]. The article focuses on the shortcomings of long cycle and low efficiency in the current teaching of welding skills in vocational colleges, adopts task driven and equipment maintenance virtual welding guidance practical teaching, and comprehensively introduces the "integration of Theory-Virtuality-Reality" teaching method to complete the entire operation process. This

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teaching mode fully exploits the subjective initiative of students, effectively improves their operational ability level, and realizes efficient and quick mastery of repair welding skills.

## 2. Practical teaching requirements for equipment maintenance welding

Vocational colleges should have a good orientation in teaching objectives, content, and methods in cultivating equipment maintenance and welding skilled talents, in order to facilitate the application of various teaching modes. The practical teaching requirements for equipment maintenance focus on being close to task needs, close to job requirements, and on the operation, use, maintenance, fault diagnosis, and troubleshooting of equipment [2].Therefore, in terms of setting teaching objectives, it is required to analyze the typical job positions, typical work tasks, work processes, and professional action abilities of operational skill training based on the talent training plan required for the job position, and set the training objectives for this course. In the design of teaching content, it is required to use the maintenance tasks of the position as the carrier, and use the "action-oriented teaching method" to continuously cultivate students' practical abilities, so that they can adapt themselves to the requirements of the professional position as soon as possible; In the specific teaching process, it is required to use a combination of action oriented teaching methods such as "brainstorming, project-based teaching, and task driven teaching" to organize teaching, embodying the concepts of "student-centered", "integration of theory and practice", and "learning by doing and doing by learning "[3].By combining work and learning, students can acquire the ability to meet the requirements of their job positions, and cultivate them into highly skilled personnel in equipment maintenance and welding.

## 3. Construction of the "integration of Theory-Virtuality-Reality" Maintenance Welding Skill Teaching Mode

For the cultivation of welding skilled talents, the traditional teaching mode generally adopts a segmented teaching mode of theory followed by practice, with the core being the integration of theoretical knowledge and practical operation. This integrated teaching method of theory and practice has been applied to various course operation skill training, and its application effect and adaptability are also different. With the development of virtual simulation technology and the widespread use of information technology in teaching, simulation teaching has become a trend that urgently needs to be promoted. For example, establishing a virtual welding training room and utilizing a virtual practice teaching platform can help solve the gap between knowledge and practical skills acquisition[4]. Compared to the traditional "theory with reality" integrated teaching mode, "integration of Theory-Virtuality-Reality" teaching has more novelty and advantages, as shown in Table 1. From the comparison of the teaching process and characteristics of the two teaching modes, it can be seen that the new "integration of Theory-Virtuality-Reality" teaching mode has the advantages of welding process visualization, quality evaluation quantification, and training consumption minimization. Therefore, constructing a task driven "integration of Theory-Virtuality-Reality" teaching mode can be effectively applied in practical teaching of welding professional skills.

**Table 1** Comparison of Two Different Teaching Modes

| Teaching model | Integrating theory and practice | Integration of Theory-Virtuality-Reality |
|---|---|---|
| **Teaching process** | Theory+Practice | Theory+Virtual+Practice |
| **Teaching characteristics** | Long time to master skills<br>High material consumption<br>Poor quality inspection<br>High security risks | Visualization of welding process<br>Minimize training costs<br>Quality evaluation quantification |

The task driven "integration of Theory-Virtuality-Reality" teaching is based on the implementation background of equipment maintenance welding tasks. Virtual simulation software is also introduced in the teaching of the course to simulate welding operations, and the interactive practice process in the virtual operating environment is used to reduce the cognitive load of students, meanwhile, cultivating students' ability to solve complex problems and higher-order thinking abilities, gradually achieving the parallel cultivation of professional knowledge and practical skills to deepen knowledge understanding [4]. If the virtual simulation operation meets the training requirements, offline practical operations will be carried out, and task assessments will be conducted. The task driven "integration of Theory-Virtuality-Reality" teaching mode strives to integrate process knowledge, operational skills, professional qualification assessment requirements, and professional literacy cultivation into the entire task. Combining the teaching characteristics of welding technology and practical training courses, the internship subjects are gradually further organized and modularized in terms of training methods, gradually simplifying the absorption of knowledge and smooth operation of skills.

## 4. Teaching Practice of Task Driven "integration of Theory-Virtuality-Reality" Mode

In the training of equipment maintenance welding skills, in order to improve the macro maintenance welding ability of talents, it is necessary to construct an equipment maintenance project carrier, and then adopt a task driven "integration of Theory-Virtuality-Reality" teaching mode for teaching practice[5].The main characteristic of this teaching mode is to emphasize the teaching application effect in practical courses, highlight the cultivation of students' good hands-on ability and innovative ability, and promote the generation and deepening of students' logical thinking ability[6]. The mode mainly includes three stages, namely the task introduction stage, task implementation stage, and task assessment stage. The core of the teaching process is the integration process of "integration of Theory-Virtuality-Reality" in practical subjects. During the task implementation stage, according to the specific requirements of the course teaching objectives and work tasks, the following three steps should be carried out in sequence, namely "process knowledge explanation, virtual welding operation, and on-site welding operation", with the purpose of achieving the mutual integration of knowledge and skills in the teaching process, and solving practical welding problems from simple to difficult, as shown in Figure 1.

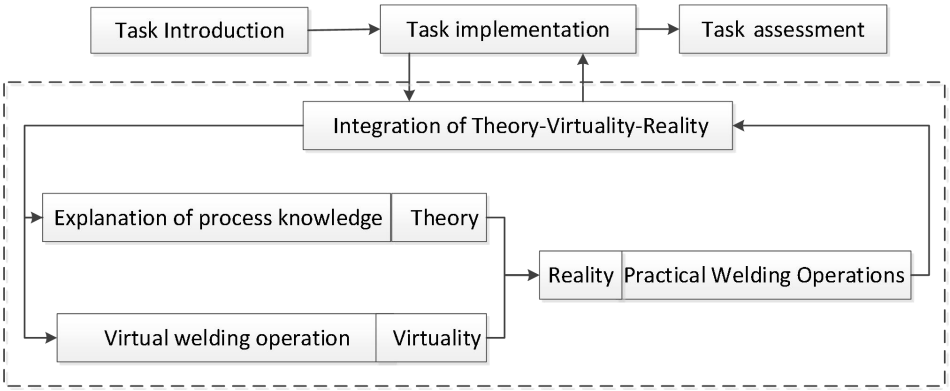


**Figure 1:** Task driven "integration of Theory-Virtuality-Reality" Teaching Mode

### 4.1. Stage 1: Task introduction and creation of context

The task introduction of practical operation subjects mainly involves combining simple welding subjects to find equipment maintenance failure cases, and then describing in detail how to extend and transform the damage and fracture problems that occur on equipment into simple welding operations between plates or pipe fittings. For example, in conjunction with the maintenance welding operation of a certain equipment support leg, as shown in Figure 2, the left figure shows the leveling support leg of a certain type of equipment. Based on its damaged parts, the structural composition is mainly analyzed as the angular welding operation of the transverse plate and the vertical plate. The model is simplified, mainly for the welding of the rib reinforcement between the cylinder and the disk, and positioned at a certain angle with the two. Therefore, the practical operation subject content of this lesson is introduced: flat fillet welding operation. Firstly, the teacher should introduce the flat fillet welding training subject into classroom teaching at appropriate times, and emphasize the purpose orientation of this practical training subject to the students. Then, the students discuss with each other about the precautions for flat angle welding operation, and learn how to choose the reasonable process parameters during flat angle welding,Finally, students are able to train specimen diagrams based on flat fillet welding standards, understand the main content and practical specifications of this lesson, and proceed to the next step of learning operational skills.

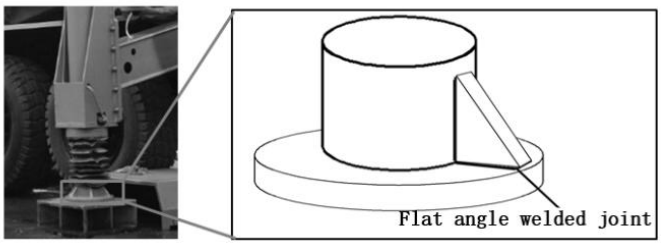


**Figure 2:** Equipment Maintenance Welding Tasks

### 4.2.Stage 2: Task implementation, integrated promotion

Step 1: Explanation of process knowledge. Only through theoretical explanation of fault repair welding technology can we lay a solid foundation for the process of welding ability level. In the process of explanation, we can use the online and offline mixed mode to cultivate teaching, such as integrating digital resources such as videos, words, exercises, and online social networking tools with screen courses to form a resourceful and diversified online course [7], so as to give students a more vivid and specific display of the operation process, It can also simplify and deepen the mastery of process knowledge. At the same time, before implementing welding, it is necessary to highlight the cultivation of students' hands-on operation ability and the ability to generate comprehensive repair welding plans [8]. Maintenance welding steps should be formulated based on the standardization of welding repair, in the order of pre welding preparation, process parameter determination, welding operation, and post welding treatment. Emphasis should be placed on mastering the basic knowledge in each step: firstly, analyze the various preparation work before the flat angle welding operation; The second is to understand the process parameter requirements of flat fillet welding; The third is the overall operation process of flat fillet welding, such as welding angle and strip transportation method, as shown in Figure 3; The fourth is to master the quality evaluation of post welding treatment.

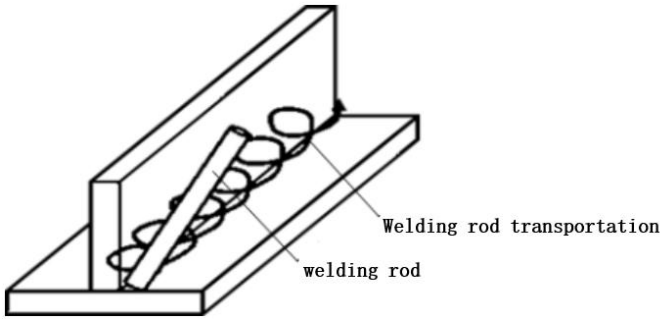


**Figure 3** Circle shaped strip transportation method for flat fillet welding

Step 2: Virtual welding operation. Virtual simulation mainly integrates multimedia resources to provide highly simulated and visualized teaching content, creating practical teaching scenarios with a sense of presence, immersion, and interactivity [9]. Based on this teaching content, each learning group is required to develop a flat fillet welding operation plan based on the flat fillet welding specimen diagram; and then students are guided to simulate the flat fillet welding operation process according to the operation specifications with the support of virtual simulation software, and submit the results of virtual welding to the teacher's end. By conducting simulation operations, it is possible to master the selection of strip angle and process parameters, as shown in Figure 4. From the figure, it can be seen that the virtual welding simulation software screen can display the dry elongation of the current welding arc in real time, as well as data such as voltage and current. These parameter data can facilitate students to monitor and feedback on the quality of the operation in real time. Through virtual welding simulation training, students simulate experimental operations in real welding, accumulate learning data and experimental operation data, and form a report as a guiding basis

for the advancement of experiments in real scenarios, in order to avoid similar welding errors that may cause failure in maintenance in real welding [4]. By utilizing the entire welding process of virtual welding, students can further master the operation steps of flat fillet welding, grasp the key points of learning, and strengthen the application of the overall operation process of flat fillet welding in equipment maintenance welding.

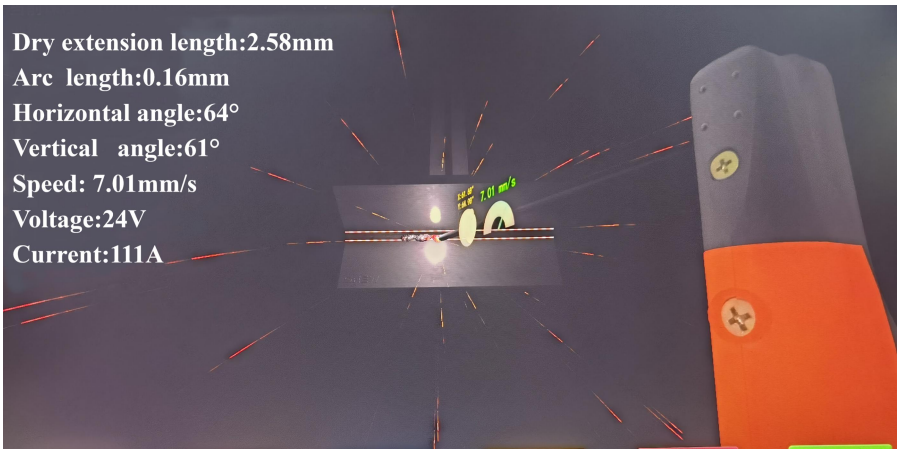


**Figure 4** Practice through virtual welding

Step 3: On site welding operation. Practical operations enhance operational skills. There are still certain differences between online virtual simulation operations and real welding operations, such as the system's realism, natural interaction, and artificial intelligence. Therefore, it must be combined with specific practical operations to achieve its intelligent effect. After guiding each group to confirm the welding plan, the teancher assigns the students the flat fillet welding training task. For the practical subjects, they should choose to conduct it in conditions close to the actual combat environment as much as possible, such as harsh outdoor conditions and special weather conditions. Gradually, the shift from the classroom to the training ground and from the operating platform to the battlefield equipment should be achieved. During the hands-on operation process of the students, the teancher continuously inspects and guides them to avoid operational errors caused by discomfort in conversion. The teancher provides difficult guidance and professional demonstration for the students, and timely corrects the various welding parameters and welding methods operated by the students during the welding process. Through practical operation, not only can the mastery of theoretical knowledge be verified, but also the guidance of virtual simulation welding for operation can be further verified, which can effectively promote the improvement of students' practical ability, further consolidate and improve the theoretical knowledge system, and quickly and accurately carry out welding repair operations.

### 4.3.Stage Three: Task Assessment, Breakthrough Difficulties

After the students have completed the practical operation, the teancher guides them to review the virtual welding operation video and compare the results of practical welding between each group. Based on the assessment rules for flat fillet welding task standards, the teancher checks

the size of the welding legs and the difference in weld width item by item, analyzes the existing problems, and conducts task assessment based on the assigned score and deduction standards. Then, through student self-assessment and group mutual evaluation, discuss the inappropriate aspects of the operation process and explore corresponding solutions and countermeasures. Finally, the teancher will explain and summarize the specific steps and essentials of flat angle operation based on the results of the students' operations, helping them overcome the difficulties and key points in their learning.Through the promotion of this task assessment mode, students can independently adjust and optimize the welding plan for repairing workpieces under the guidance of the instructor's evaluation.

## 5. Analysis of the Practical Effect of the Application of the “integration of Theory-Virtuality-Reality" Teaching Model

(1) Through the task driven process of the "integration of Theory-Virtuality-Reality" teaching mode in three stages of teaching, specific teaching tasks and objectives are set step by step. During the process of the teaching of teachers and the learning of students/ During the process of interaction between the teacher and students, a model framework for vocational skill development has been constructed to enhance the professional orientation of the position, enabling students to use the knowledge and skills they have learned to solve repair welding problems in a timely manner. At the same time, it enriches the content, methods, and methods of classroom teaching skill training.

(2) Through the implementation of tasks in the three link teaching mode of "integration of Theory-Virtuality-Reality", the learning subject status of skilled talents is highlighted. For the same skill training content, focusing on key and difficult points, this teaching mode is gradually carried out from three levels: theoretical knowledge, virtual operation, and practical operation, to achieve theory in practice and practice in theory. This teaching mode enables students to take the initiative to learn active learning, complete the task requirements through group cooperation, and find problems, explore problems, and finally solve problems during the implementation process [10], so as to deepen the grasp of knowledge and skills, with the aim of cultivating the students' hands-on ability and professional skills, fully mobilizing and stimulating their interest in learning.

(3) The "integration of Theory-Virtuality-Reality" teaching mode breaks the segmented teaching mode of "theory first, then practice", and realizes the integrated mode of "teaching and doing" in equipment maintenance welding. After theoretical teaching of process knowledge, virtual operations are carried out on the key and difficult points of the course. Once theoretically proficient, they can operate on actual equipment. The theoretical knowledge explanation and hands-on operation training are closely combined, achieving the goal of "learning by doing, doing by learning" [11], effectively improving students' practical skills and improving the quality of classroom teaching.

The study show that the application of the "integration of Theory-Virtuality-Reality" teaching mode in practical teaching has greatly improved the satisfaction with the improvement of teaching effectiveness, especially for the average passing rate of welder professional skill appraisal. According to data statistics from vocational colleges, the overall passing rate has increased from 75% to 90%, an increase of about 15%, achieving good application effects. A

questionnaire survey among students shows that this teaching mode can effectively improve students' hands-on and innovative abilities [12], providing knowledge accumulation and ability support for students to engage in work after they return to their positions/laying a solid foundation for their future career development.

## 6. Summary

The task-driven "integration of Theory-Virtuality-Reality" teaching mode for equipment maintenance and welding is driven by work tasks. Through three stages of task introduction, task implementation, and task assessment, the orderly connection of the teaching process is achieved. In the task implementation stage, the three teaching links of "theory, virtual, and reality" are integrated into it, achieving the teaching tasks and goals of the course.

In the subsequent teaching process, it is necessary to continuously strengthen the informatization and visualization of theoretical knowledge explanation, the feedback effect of virtual simulation technology more realistic, and the evaluation of practical operation quality more standardized. Only in this way can this teaching mode be better applied to various equipment maintenance and support.

## References


[1] Wu Wenyou, Tang Hailong, Pan Qihua. Construction of an Intelligent War Equipment Maintenance Support System [J]. Journal of Military Transportation, 2022,1 (08): 43-47+51.

[2] Fang Qiuyi. Exploration of Teaching Reform for Non commissioned Officer Practice Course in Equipment Maintenance and Support Major [J]. Vocational and Technical Journal, 2022, 21 (05): 90-95.

[3] Chen Yu, Xiao Yifeng, Li Xiangwen. Exploration of the Teaching Reform of the "integration of Theory-Virtuality-Reality" Course "Welding Robot" in the New Engineering Science [J]. Electric Welding Machine, 2020,50 (12): 104-107.

[4] Lu Xing, Zhu Tao, Xu Jingjing, Zhang Liping. Basic Issues and Trends in Virtual Simulation Experimental Teaching in Universities [J]. Modern Education Technology, 2021,31 (12): 61-68.

[5] Fan Xinbo, Wang Guihong. Research on the Teaching Reform of Welding Majors in Higher Vocational Education Based on the integration of Theory-Virtuality-Reality [J]. Xinjiang Vocational Education Research, 2019,10 (02): 34-36.

[6] Shen Jinxing, Gong Piping, Gao Yaming, Yang Xiaoqiang. Reform and exploration of practical teaching for mechanical fault diagnosis with the goal of ability guidance [J]. Mechanical Management Development, 2021,36 (05): 247-248+254.

[7] Ye Fei, Liao Chengzhu, Zhang Jianbo, Li Yanyan, Li Huili. Experimental Teaching of Deep Integration of MOOC and Virtual Simulation [J]. Journal of Beijing University of Science and Technology (Social Science Edition), 2022-38 (01): 67-72.

[8] Yuan Xiaojing, Wang Xuping, Li Ping, Yang Nengjun, Liu Guodong. Professional Curriculum Reform Practice Focusing on Practical Maintenance Support in the Context of New Engineering [J]. Journal of Higher Education, 2021 (05): 163-166.

[9] Yin Jun, Li Lulu, Qi Xinlei, Ge Shilun, Qian Ping. Research on Factors Influencing the Learning Effect of Virtual Simulation Teaching System [J]. Modern Education Technology, 2022,32 (01): 64-74.
[10] Huang Peng; Tan Lanlan Construction of the teaching mode of "four steps integration of law, theory, falsehood and reality" under the background of "Internet plus" - based on the electrical courses of technical schools [J]. Electronic World, 2020 (11): 76-77.
[11] Gilly; Zhang Hengheng; Liu Li; Michunzi; Yang Xiaoqian. Design and Practice of an Integrated Training Course on "Theory-Virtual-Real" for Automotive Connecting Fasteners [J]. Science and Technology Information, 2020 (04): 118-119+121.
[12] Li Dan. Reform and Practice of the Teaching Model of "integration of Theory-Virtuality-Reality" in Higher Vocational Education Based on Workpages [J]. Journal of Hubei Radio and Television University, 2020 (03): 44-48.