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Integration of Teaching Resources and Practical Innovation of Mechatronics Comprehensive Training Under the Background of New Engineering

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Abstract

Driven by global industrial upgrading and technological innovation, the concept of "New Engineering" has emerged, aiming to cultivate interdisciplinary and compound engineering talents. As a typical interdisciplinary field, mechatronics holds great application potential in cutting-edge areas such as intelligent manufacturing. However, traditional teaching models and resource allocation are no longer sufficient to meet the industry's growing demands for practical skills and innovation capabilities. This study focuses on the integration and innovation of mechatronics practical training resources under the background of New Engineering, aiming to enhance the quality of practical teaching and better serve the needs of current and future industrial development.This paper explores the topic from four key perspectives: First, it analyzes the current status and existing problems of mechatronics practical training resources and proposes strategies for integrating hardware, software, teaching staff, and social resources. Special attention is given to the use of modern information technologies such as cloud computing, big data, and virtual simulation to improve resource utilization, sharing, and interactivity. Second, it investigates innovative teaching models such as project-based learning (PBL), flipped classrooms, school-enterprise cooperation, and virtual simulation combined with hands-on practice, with the goal of enhancing students' engineering thinking and problem-solving abilities. Third, by analyzing successful cases from typical universities and enterprises, the paper summarizes effective approaches and practical pathways for resource integration and teaching innovation. Finally, it offers a forward-looking discussion on the future development of mechatronics education, emphasizing the promotion of intelligent and digital teaching models and the deep integration of industry, academia, and research.The results show that school-enterprise cooperation significantly improves students' practical abilities, innovative thinking, and teamwork skills through integrated resources and innovative teaching. Students demonstrate higher satisfaction with practical training and outperform those under traditional teaching models in terms of hands-on skills, creativity, and collaboration. In conclusion, under the framework of New Engineering, integrating resources and innovating teaching methods in mechatronics can effectively cultivate high-quality talents aligned with modern industrial needs. In the future, the focus should be on intelligent teaching, the application of virtual reality technologies, interdisciplinary integration, deepened school-enterprise collaboration, and the comprehensive integration of production, education, research, and application.

Keywords: New Engineering; Mechatronics; Internship; School-Enterprise Cooperation; Innovation of Teaching Model

1. Introduction

With the continuous development of the global economy, scientific and technological innovation and industrial upgrading have become important driving forces for economic growth in various countries. In recent years, the industrial structure has undergone profound changes worldwide. Emerging industries such as intelligent manufacturing, industrial Internet, and robotics technology have continued to rise, and traditional manufacturing is facing huge challenges of transformation and upgrading (Zhao & Wei, 2019; Wang & Zhao, 2020). Against this background, "new engineering" came into being and became an important way to closely connect higher education with industrial development (Wang & Li, 2020; Li & Liu, 2021). The core concept of new engineering is to cultivate interdisciplinary and compound engineering and technical talents to adapt to the increasingly complex and changing needs of science and technology and industry.

In the context of new engineering, mechatronics, as a typical interdisciplinary subject, is gaining more and more attention. Mechatronics integrates advanced technologies from multiple disciplines such as machinery, electronics, computers, and automation, and is the foundation of modern manufacturing and intelligent systems (Chen & Zhou, 2020; Yang & Li, 2020; Lin & Ding, 2021). It not only occupies an important position in traditional manufacturing, but also shows great application potential in cutting-edge technology fields such as intelligent manufacturing, industrial robots, automated control, and unmanned driving. The core task of mechatronics is to organically combine mechanical and electronic technologies to improve production efficiency and product quality through automation and intelligent means.

Especially in China, the country vigorously promotes the strategy of manufacturing power and actively advocates intelligent manufacturing and industrial upgrading (Zhang & Xue, 2020; Zhang & Li, 2021; Chen, 2020). As an important discipline supporting this strategy, the development of mechatronics not only helps to enhance the competitiveness of the industry, but also provides strong support for promoting scientific and technological innovation and improving the level of production automation. With the continuous advancement of science and technology, the application scenarios of mechatronics have expanded to more diverse fields, such as industrial robots, intelligent equipment, unmanned driving, smart cities, etc., which requires mechatronics talents to not only have a solid engineering foundation, but also have interdisciplinary innovation capabilities and the ability to solve complex problems.

However, the training of mechatronics talents faces a series of challenges. Traditional teaching models and resource allocation can no longer meet the needs of modern industries for talents, especially in cultivating students' practical ability and innovation ability. There is still a large gap. Therefore, exploring how to optimize the mechatronics teaching system under the background of new engineering, especially how to improve students' practical ability and innovative thinking through comprehensive practical training teaching, has become an important issue that needs to be solved urgently.

2. The Current Status of Mechatronics Education Under the Background of New Engineering

2.1. Definition and Characteristics of New Engineering

New engineering is a new concept of higher education reform proposed by China in recent years. It aims to cope with the increasingly complex and rapidly changing technological and industrial needs of modern society and promote the cultivation of high-quality engineering and technical talents that can adapt to the future industrial and social development (Liu & Cui, 2020; Chen et al., 2021; Liu et al., 2021). The core concept of new engineering is to break through the disciplinary barriers of traditional engineering, focus on interdisciplinary integration, attach importance to the cultivation of practical innovation and engineering capabilities, and closely connect with industrial and social needs.

Specifically, the characteristics of new engineering include: Interdisciplinary integration: New engineering not only focuses on the technical accumulation of a single discipline, but also pays more attention to the coordination and integration between different disciplines. For example, mechatronics is an organic combination of multiple disciplines such as machinery, electronics, automation, and computers (Yang & Gao, 2020; Liu & Wang, 2021). It requires students to cross the boundaries of disciplines, master knowledge in multiple fields, and have strong comprehensive application capabilities. Practice and innovation orientation: New engineering education emphasizes the cultivation of engineering practice and innovation capabilities. The traditional theoretical teaching model can no longer meet the society's demand for talents (Wang & Ma, 2020). Students must consolidate their knowledge through practice and cultivate the ability to solve practical problems. Therefore, practical teaching and the cultivation of innovation capabilities have become one of the key elements of new engineering. Deep docking with industry: New engineering requires universities to work closely with industry enterprises to ensure that teaching content and curriculum settings can meet the needs of current and future industries (Wang & Sun, 2019; Wang & Zheng, 2021). By introducing real projects and technical applications of enterprises, students can keep abreast of industry trends and technological frontiers and enhance their employment competitiveness. Focus on diversified talent training models: New engineering emphasizes personalized and diversified training paths, and requires flexible teaching methods such as project-driven learning and engineering problem-solvingoriented teaching to better stimulate students' innovative potential and independent learning ability according to different student characteristics. Therefore, new engineering is not only an update of subject content, but also an innovation of educational concepts and training models. It requires higher education to reform and innovate in multiple aspects such as curriculum setting, teaching methods, and practice platforms.

2.2. Characteristics of Mechatronics

As an important part of the new engineering discipline, mechatronics is a combination of multiple disciplines such as mechanical engineering, electronic technology, computer science, and automatic control (Gao & Wu, 2020; Han & Yuan, 2021; Li & Zhao, 2021). The development of mechatronics is closely related to the development of modern manufacturing, especially in the fields of intelligent manufacturing, industrial robots, and automatic control systems. It provides technical support for the transformation and upgrading of the industry.

Discipline characteristics: Mechatronics has typical interdisciplinary characteristics. It not only requires students to master the basic theories and methods of mechanical design and manufacturing, but also requires students to be familiar with electronic circuits, automatic control, computer programming and other technologies (Liu & Tang, 2021). Therefore, the training goal of mechatronics is to enable students to have a multidisciplinary knowledge structure and comprehensive application ability. Students should not only understand the principles of a single discipline, but also learn how to integrate and apply the technologies of various disciplines.

Development history: As an emerging discipline, mechatronics originated from the combination of mechanical engineering and electronic technology. With the rapid development of information and automation technology, mechatronics has gradually expanded to more complex application fields such as intelligent control and robotics (Tang & Shi, 2021; Tang & Li, 2020). It has extended from traditional mechanical processing and equipment control to high-tech fields such as intelligent manufacturing, digital factories, and unmanned driving, becoming an important part of modern manufacturing.

Wide application: Mechatronics technology has a wide range of applications in modern manufacturing, covering intelligent manufacturing, automated production lines, industrial robots, intelligent equipment, drones, unmanned driving and other fields. These applications not only improve production efficiency and reduce production costs, but also promote fundamental changes in production models. Therefore, mechatronics is not only a product of technological development, but also an important manifestation of modern industrial competitiveness.

2.3. Current Educational Situation in The Field of Mechatronics in Domestic and Foreign Universities

Globally, especially in developed countries, mechatronics education has received widespread attention and is closely linked to industrial development. Many universities have promoted the integration of industry, academia and research through cooperation with enterprises, and provided teaching content and courses that meet the needs of the industry. However, domestic education in this field still faces some problems.

The teaching content is not connected with industrial needs: At present, the mechatronics courses of many universities are still based on traditional mechanical and electronic knowledge. Although emerging technology content such as intelligent manufacturing and industrial Internet has been introduced in recent years, the update and adjustment of the curriculum system are relatively lagging (Wang & Zhou, 2020). The rapid development of the industry requires universities to integrate cutting-edge technologies into teaching content in a timely manner, but the existing textbooks and course content often cannot meet this demand.

Aging training equipment and insufficient practical teaching resources: The mechatronics experimental equipment and training platforms of many universities are relatively old and cannot meet the needs of students' practical operations. Especially in some small and medium-sized colleges and universities, insufficient funds and untimely equipment updates have greatly reduced the learning effect of students in the practical link. The imperfection of experimental teaching facilities makes it difficult for students to access advanced technologies and equipment, which in turn affects the cultivation of students' practical and innovative abilities.

Single teaching mode: Although mechatronics is a highly practical discipline, many universities still rely on traditional classroom lectures and lack effective practical teaching methods. Traditional teaching methods fail to meet the actual needs of modern industry, resulting in students lacking sufficient practical experience and the ability to solve complex engineering problems after graduation.

2.4. Necessity and Challenges of Comprehensive Training in Mechatronics

The comprehensive practical training teaching of mechatronics plays a vital role in cultivating students' practical operation ability and engineering practice ability. It not only helps students transform theoretical knowledge into practical skills, but also cultivates their ability to solve practical problems, which is crucial to improving students' employment competitiveness.

The importance of practical training: Practical training is an indispensable part of mechatronics education. Through real experiments and projects, students can better understand and master the integrated application of various disciplines and improve their hands-on ability and engineering practice ability. Especially in cutting-edge fields such as modern intelligent manufacturing and robotics, students can understand the application of related technologies more deeply through practical operations and cultivate the ability to solve complex engineering problems.

Problems in current practical training teaching:

Slow equipment update: The mechatronics practical training equipment of many universities is relatively old and cannot meet students' needs in the application of new technologies. With the continuous development of industrial technology, new intelligent manufacturing equipment, automatic control systems, industrial robots, etc. have gradually entered the production field, but the practical training platforms of many universities are still based on traditional equipment and cannot be updated in time.

Few opportunities for practical operation: Although some universities have established mechatronics training courses, students still have limited opportunities to participate in practical operation due to limitations in equipment, venues, funds, etc. Some students can only operate on simulation experiments or virtual simulation platforms and lack the experience of face-to-face problem solving.

Insufficient teaching ability of teachers: The teaching content of mechatronics education is complex and involves multiple disciplines. Teachers are required to have not only solid professional knowledge, but also interdisciplinary teaching ability and engineering practice experience. However, the teaching team of some universities has certain difficulties in updating teaching content and project-driven teaching, and it is difficult to meet the requirements of new engineering teaching.

2.5. Integration of Mechatronics Training Teaching Resources

As an interdisciplinary subject, mechatronics has multiple teaching resources, including hardware resources, software resources, human resources, and case resources. The effective integration of each type of resources directly affects the quality of mechatronics education and the cultivation of practical ability. Therefore, fully understanding the types and composition of these resources is of great significance to promoting the development of mechatronics education.

2.5.1. Hardware Resources

Hardware resources are the most basic and critical component of mechatronics education, mainly including various mechatronics related equipment, laboratory facilities, experimental platforms and virtual simulation platforms. Specifically, hardware resources mainly include:

Mechatronics equipment: including CNC machine tools, industrial robots, automated production lines, intelligent equipment, sensors, actuators and other equipment. These equipment can help students understand and master the core technologies of mechatronics from actual production, such as automatic control, mechanical design and manufacturing, sensing and execution technology, etc.

Laboratory facilities: Mechatronics education usually requires the support of multiple professional laboratories, such as mechanical design and manufacturing laboratories, electronic technology laboratories, automatic control laboratories, robotics laboratories, etc. The construction of laboratory facilities should not only be equipped with high-quality equipment, but also meet the needs of various experiments to support students to explore and apply the knowledge they have learned in practice.

Virtual simulation platform: With the advancement of technology, virtual simulation platforms have become one of the indispensable resources in mechatronics education. These platforms can simulate various scenarios in industrial production and help students conduct virtual experiments and simulation operations. Through virtual simulation, students can conduct experiments without actual equipment and understand the operating procedures and principles of the equipment in advance. Especially when equipment resources are limited, it can effectively make up for the shortcomings of traditional training.

2.5.2. Software Resources

The education of mechatronics not only relies on hardware resources, but also software resources are crucial. The following are the main software resources:

Computer simulation software: such as MATLAB/Simulink, LabVIEW, AutoCAD, etc. These software can help students with mechanical design, control system modeling and simulation, data analysis and processing, etc. The use of computer simulation software not only improves students' practical operation ability, but also deepens students' understanding of engineering principles, especially for the modeling and simulation analysis of complex systems.

Control system software: such as PLC programming software, DCS system, SCADA system, etc. These software are the core components of modern industrial automation control systems, which can help students learn how to design, program and debug automation control systems. Through the operation of the software, students can realize the control and scheduling of automation equipment and further deepen their understanding of automation technology.

Learning platform: various online learning platforms, MOOC (massive open online course) platforms, virtual experiment platforms, etc. can also serve as important educational resources. These platforms provide rich course resources, teaching videos, interactive learning tools and online discussion areas, providing students with flexible learning methods, especially in distance learning and self-learning. There is great potential.

2.5.3. Human Resources

Human resources play a vital role in mechatronics education. The professional quality and teaching ability of teachers directly determine the teaching effect. In addition to teachers within colleges and universities, corporate mentors and external experts are also important forces to improve teaching quality. Specifically:

Teacher quality and ability: Mechatronics disciplines require teachers to have not only solid basic knowledge of the subject, but also rich practical experience and interdisciplinary teaching ability. Teachers need to constantly update their knowledge system and master new technologies, new equipment and new software to ensure the advancement and practicality of teaching content. In addition, teachers also need to have good teaching design and innovation capabilities, and be able to design flexible teaching models according to students' learning needs.

Corporate mentors and external experts: By introducing corporate mentors and external experts, students can be exposed to more cutting-edge industry technologies and practical application problems. Corporate mentors usually have rich project experience, can provide professional guidance to students, and bring specific problems in practice into the classroom to enhance students' engineering practice ability.

2.5.4. Case Resources

Case resources are an important part of mechatronics practical training. Case resources include typical industrial project cases and successful school-enterprise cooperation cases, which are mainly used to cultivate students' engineering practice ability and innovative thinking.

Typical industrial project cases: By introducing typical project cases in the industry, students can understand the industry needs, technical standards, engineering design and the entire process of implementation. These cases not only help students apply theoretical knowledge to actual projects, but also enhance their ability to solve practical problems.

School-enterprise cooperation cases: School-enterprise cooperation is an important resource in mechatronics education. By cooperating with enterprises, schools can obtain the latest technical information, equipment resources and engineering projects, and enterprises can provide students with real project cases and training platforms. In addition, school-enterprise cooperation can also provide students with internship and employment opportunities to help them better integrate into society and the industry.

3. Strategies and Methods of Resource Integration

Resource integration of mechatronics education is a systematic project, which requires effective strategies and methods to promote the deep integration and optimization of hardware, software, and human resources. The following are several feasible resource integration strategies and methods:

3.1. School-Enterprise Cooperation and Introduction of Social Resources

School-enterprise cooperation is an important way to promote the integration of mechatronics practical teaching resources. Through close cooperation with enterprises, schools can obtain the latest industrial projects, equipment resources and technical support, and enterprises can provide schools with real production cases and problems to help students better understand industry needs.

Jointly build a practical training platform: Schools can cooperate with enterprises to jointly build a practical training platform with advanced equipment and cutting-edge technology, so that students can be exposed to the latest equipment and technology and adapt to the industrial environment in advance.

Support from corporate mentors and industry experts: By introducing corporate mentors and industry experts, schools can provide students with more realistic and challenging practical training tasks. At the same time, corporate mentors can also provide students with project guidance to help them accumulate experience in practice.

Internship and employment opportunities: School-enterprise cooperation can also provide students with more internship and employment opportunities. Enterprises can provide career development opportunities based on students' performance, which not only helps students' career planning, but also strengthens the cooperative relationship between schools and enterprises.

3.2. Construction of a Comprehensive Teaching Platform

In order to improve the utilization efficiency of teaching resources, hardware, software and human resources can be integrated and shared by establishing a comprehensive teaching platform. This platform can include the following:

Hardware resource sharing: Through the network platform, remote operation and resource sharing of experimental equipment can be realized. For example, cloud platforms and Internet of

Things technologies can be used to enable equipment distributed in different locations to be managed and operated on a unified platform, and students can remotely control equipment to conduct virtual experiments and actual operations.

Software resource sharing: By sharing computer simulation software, control system software, etc., students can collaborate on the cloud platform and use the latest software tools for experiments and simulation operations, avoiding the waste of software resources and management difficulties.

Teacher and expert resource sharing: By establishing an online teaching platform and interactive community, teachers and external experts can provide guidance and support to students in real time. At the same time, teachers can publish teaching content, organize online discussions and answer questions through the platform, and improve the flexibility and interactivity of teaching.

3.3. Application of Intelligent and Digital Technologies

With the rapid development of technologies such as cloud computing, big data, and the Internet of Things, the application of these technologies in the integration of teaching resources has brought great potential for change to mechatronics education.

Cloud computing and remote operation: Through the cloud computing platform, students can remotely access experimental equipment and conduct online experiments and simulation operations. The cloud platform can integrate teaching content, experimental data, and student operation records, provide efficient resource scheduling and management, and avoid idle waste of equipment resources.

Big data and data analysis: Using big data technology, schools can collect students' learning data, experimental results, operation records and other information for analysis and evaluation. Through the data analysis platform, teachers can understand students' learning progress and weak links, adjust teaching strategies in a targeted manner, and improve teaching effectiveness.

Internet of Things and intelligent teaching: Internet of Things technology can help schools monitor the operating status of experimental equipment in real time to ensure the normal use of equipment. At the same time, the intelligent teaching platform can push personalized learning content and tasks in an automated way to improve students' learning efficiency.

4. Practical Innovation of Mechatronics Training Teaching

With the rapid development of social economy and the continuous innovation of technology, the traditional teaching model can no longer meet the demand for talents in the discipline of mechatronics. Especially in the context of new engineering, mechatronics practical training teaching urgently needs to cultivate innovative talents who can solve complex engineering problems through practical innovation. This chapter will explore several innovative teaching models, including project-based learning (PBL), flipped classroom, the combination of virtual simulation and actual operation, and the combination of school-enterprise cooperation and industry-university-research, aiming to provide new ideas and paths for mechatronics education.

4.1. Exploration of Innovative Teaching Models

Project-based learning (PBL) is a teaching method driven by actual projects, which can help students explore and solve practical problems through practice, thereby cultivating their comprehensive abilities. In the discipline of mechatronics, PBL is a very effective teaching model because it puts students in a complex engineering environment and requires students to not only understand theoretical knowledge, but also be able to apply this knowledge to actual projects.

Solving real engineering problems: By allowing students to participate in real engineering projects, they can be exposed to actual technical difficulties and engineering challenges. Students need to analyze problems, develop solutions, and ultimately achieve project goals. Through this process, students can improve their ability to solve complex engineering problems, and also have a deep understanding of how subject knowledge can be applied in practice.

Interdisciplinary collaboration: Mechatronics involves multiple disciplines such as mechanics, electronics, automation, and computers. PBL can promote students' cross-disciplinary learning and collaboration among multiple disciplines. In a project, students not only complete their own tasks, but also need to work closely with team members to solve multidisciplinary technical problems. This interdisciplinary cooperation can improve students' comprehensive quality and teamwork ability.

Practicality and innovation: PBL attaches importance to the cultivation of hands-on ability. During the implementation of the project, students can not only enhance their understanding of technical details, but also exercise their innovative thinking. For example, in an automation control project, students may need to design and implement customized control algorithms according to actual needs, and this process not only exercises their theoretical knowledge, but also promotes the cultivation of innovative ability.

Project selection and design: The teaching team can design projects related to industry needs based on the course content, such as robot programming, automated production line construction, and intelligent manufacturing system optimization. The choice of projects should be challenging, allowing students to give full play to the knowledge they have learned, and the difficulty of the projects should be gradually progressive to ensure that students can improve their abilities from simple to complex.

Teamwork and role division: The PBL model emphasizes teamwork. In actual projects, students should divide the work according to their personal expertise and interests, and members of the team should collaborate with each other to share information and technology. Through teamwork, students can not only improve their professional abilities, but also learn how to communicate and cooperate with others.

Real-time feedback and evaluation: During the implementation of the project, teachers should provide continuous guidance and feedback to help students solve problems and adjust their thinking in a timely manner. At the same time, students' performance should be comprehensively evaluated through a combination of process evaluation and final outcome evaluation.

4.2. Flipped Classroom

Flipped classroom is an innovative teaching model that is opposite to the traditional teaching model. In traditional classrooms, teachers teach knowledge and students practice and review after class. The core idea of flipped classroom is to transfer the classroom teaching part to extracurricular activities, and to conduct more discussions, interactions and practices in class, emphasizing students' ability to learn independently.

Implementation path of flipped classroom:

Utilization of online resources: Teachers can use the Internet platform to upload explanation videos, reading materials, case analysis and other content, and students can learn these contents independently according to their own learning progress and interests. Through online resources, students can flexibly arrange their own learning time and improve the autonomy and personalization of learning.

Optimization of classroom time: Classroom time is more used for discussion, practice and problem solving among students. The role of teachers has changed from traditional knowledge transmitters to guides, counselors and problem solvers. In class, students can discuss project progress and solve difficult problems encountered in learning, thereby deepening their understanding and application of knowledge.

Interactive and collaborative learning: Flipped classroom emphasizes students' interaction and cooperation in class. In actual operation, students can learn through group cooperation, project drive, problem discussion and other methods to enhance teamwork ability and innovative thinking. For example, in the mechatronics course, students can work in groups to program robots and complete project design through collaboration.

Self-evaluation and reflection: Flipped classroom also encourages students to conduct self-evaluation and reflection, helping students to recognize their own strengths and weaknesses and develop improvement plans. Students can conduct self-assessment by submitting homework, taking quizzes, and taking knowledge tests on the online platform.

4.3. Combination of Virtual Simulation and Actual Operation

Virtual simulation technology is widely used in mechatronics education, especially in the current situation of limited equipment resources and insufficient experimental sites. Virtual simulation system provides an ideal solution. Virtual simulation technology can transform real-world engineering problems into digital models, help students conduct virtual experiments and operations, and thus improve their engineering practice ability.

Application of virtual simulation technology:

Virtual experiment platform: Through the virtual experiment platform, students can operate without actual equipment and familiarize themselves with the experimental process and operation skills in advance. For example, students can perform robot programming, PLC control system debugging, and automated production line simulation on the virtual platform, which provides students with a more flexible experimental method.

Digital twin technology: Digital twin technology synchronizes the operating status and control parameters of the equipment in real time by creating a virtual model that is exactly the same as the actual equipment. Students can observe the operation process of the equipment through the digital twin system, predict possible faults and debug. This technology not only improves students' operating skills, but also helps them to perform effective operation and debugging when the real equipment is not available.

Combination of virtual simulation and actual operation: Although virtual simulation technology can provide rich learning resources, it still has certain limitations, such as the lack of actual operation feel and intuitive understanding of equipment. Therefore, virtual simulation and actual operation should be used in combination. When learning a certain skill, students can first conduct preliminary operation training through virtual simulation, and then conduct actual operation to ensure that students can truly master the skills.

4.4. School-Enterprise Cooperation and Integration of Industry, Academia and Research

School-enterprise cooperation is an important resource that cannot be ignored in mechatronics education. Through cooperation with enterprises, schools can obtain the latest technical information, equipment resources, industrial projects, etc., and enterprises can also obtain more innovative thinking and technical support from schools. The combination of industry, academia and research can not only promote the development of mechatronics disciplines, but also improve the fit between teaching content and actual needs.

Implementation path of school-enterprise cooperation:

Co-construction of training platforms and R&D centers: Schools can cooperate with enterprises to co-construct training platforms or R&D centers with advanced equipment and leading technology. Enterprises provide financial, technical and equipment support, and schools are responsible for organizing teaching and scientific research activities. Students participate in real engineering projects under the guidance of enterprise mentors and gain first-hand technical experience through practice.

The actual needs of enterprises drive the update of teaching content in reverse: Close cooperation between enterprises and schools can help schools better understand industry needs and technological development trends. For example, enterprises can feedback their needs for talents and technical requirements based on the needs of actual projects, and schools can update teaching content based on these feedbacks to make teaching more forward-looking and practical.

The introduction of industry mentors: By introducing experts and mentors from the industry, students can directly contact the cutting-edge technologies and problems in the industry and understand market needs and technological development trends. Industry mentors can not only provide project guidance for students, but also help them establish career planning and development directions.

Case analysis: For example, our school has established a cooperative relationship with Guangzhou Julun Technology Co., Ltd., a local automation equipment manufacturing company, and students conduct practical training in the actual production environment of the enterprise. The enterprise provides students with real project tasks, and students implement projects under the guidance of mentors, thereby improving their practical operation ability and ability to solve engineering problems. At the same time, students' innovative solutions also provide new ideas for product improvement of enterprises.

5. Case Analysis and Training Effect Evaluation

5.1. Typical Case Analysis

In mechatronics education, the successful implementation of school-enterprise cooperation and resource integration can significantly improve students' comprehensive abilities and promote the close integration of teaching content with industry needs. The following is a specific case analysis that shows the successful experience of a certain university and enterprise in jointly training mechatronics talents.

5.2. Case Background

Our school and Guangzhou Julun Automation Manufacturing Co., Ltd., a well-known domestic intelligent manufacturing enterprise, jointly carry out a mechatronics professional talent training program. The core of the program is to provide students with an education model that is closer to market demand through joint training between schools and enterprises, sharing of educational resources, and enterprise actual project-driven teaching. Through in-depth cooperation, the two parties not only provide advanced experimental equipment, but also establish a training base based on industry needs, providing students with a practical platform that is in line with the industry.

5.3. Resource Integration and Teaching Innovation

Hardware resource integration.Enterprise equipment investment: Giant Wheel Technology has provided our school with a series of advanced industrial robot systems, including the IRB-120 six-axis industrial robot. This robot boasts a repeat positioning accuracy of ±0.02mm, a load capacity of 3kg, and a working radius of 580mm. Additionally, the company has supplied an automated production line that covers multiple stages, including material conveying, processing, and inspection. The processing unit uses high-precision CNC machine tools, achieving a processing accuracy of ±0.01mm.

Supplement to school equipment: Our school's mechatronics laboratory is equipped with basic mechanical processing equipment, electronic testing instruments, and automated control experimental devices. Through collaboration between the school and enterprises, the school's equipment complements that of the enterprises, allowing students to conduct foundational theoretical verification experiments in the school laboratory and comprehensive application practices in complex industrial scenarios at the enterprise practice base.

Equipment Update Mechanism: Each academic year, Juhuan Technology updates or upgrades the equipment provided to schools based on industry technology advancements, ensuring that the equipment students use remains at the forefront of the industry. For example, over the past two years, the company has upgraded the control system software for industrial robots in schools from version V5.2 to V6.1, adding several intelligent programming and fault diagnosis features.

Teaching innovation.Project-driven teaching: Juhuan Technology integrates real-world projects into the educational process. For instance, in the 'Intelligent Warehouse and Logistics System' project, students are involved in the sub-project of robot path planning for cargo handling. The company mentors break down the project into several stages based on its progress, including requirement analysis, solution design, algorithm development, and system testing. Students must submit their work at each stage. In the requirement analysis phase, students research the specific needs of robot handling in warehouse logistics settings, such as cargo size, weight, and handling paths, and compile a detailed report. In the solution design phase, student teams develop an initial plan for robot path planning and conduct preliminary validations using simulation software. The company mentors review the plans and provide feedback for improvement. In the algorithm development phase, students write the code for the robot path planning algorithm based on the plan and debug it on a virtual simulation platform. In the system testing phase, students deploy the developed algorithm to actual industrial robots for on-site testing and optimization, ultimately achieving efficient and stable handling in warehouse logistics scenarios.

Teaching content updates: The school adjusts its curriculum in a timely manner based on the project requirements and industry trends provided by Giant Wheel Technology. For instance, in the 'Automation Control System' course, new case studies have been added to explore the application of industrial IoT technology in automation control, detailing how IoT technology enables interconnectivity and remote monitoring between devices. In the 'Robotics Technology' course, the latest developments in collaborative robot programming and operation have been integrated, covering topics such as the safety features of collaborative robots and human-machine interaction technologies, ensuring that the teaching content closely aligns with real-world applications in the industry.

Evaluation of Practical Teaching Effectiveness: Data Collection Tools and Methods. The school has developed a practical operation assessment system to record students 'operational data during the practice process. This system is installed in the school's mechatronics laboratory and the equipment at Juhuan Technology's practice base, capable of collecting real-time data on the time, steps, and accuracy of students' operations. For instance, in the industrial robot programming and operation assessment, the system can track the time it takes for students to complete a specific task (such as moving a workpiece to a designated position), with precision down to seconds. It also records the number of errors made during the operation, such as programming errors or command errors. Project Outcome Evaluation Platform: Enterprises have established a project outcome evaluation platform to assess the quality of student projects. This platform, composed of technical experts from enterprises and school teachers, evaluates the project outcomes from multiple dimensions, including technical implementation, innovation, and practicality. For example, in the intelligent warehousing logistics system project, the evaluation team assesses the accuracy of the robot's path planning, handling efficiency, and system stability. Each dimension is scored out of 100 points, and the final score for the student team is the weighted average of these scores. Quantitative Comparison Data: Improvement of Practical

Operation Skills: By comparing the data collected through the practical operation assessment system, the improvement in students' operational skills under the traditional teaching model and the innovative teaching model of school-enterprise cooperation can be evaluated. Under the traditional teaching model, students typically take an average of 120 seconds to complete industrial robot handling tasks and make an average of 5 operational errors. In contrast, under the school-enterprise cooperative innovative teaching model, the average time for completing the same task is reduced to 90 seconds, and the number of operational errors is reduced to 2. This indicates that the school-enterprise cooperative innovative teaching model has significantly enhanced students 'practical operational skills. The quality of project outcomes has also improved: by comparing the scores from the project outcome evaluation platform, we can see that under the traditional teaching model, student teams scored an average of 60 points on the intelligent warehousing logistics system project; under the school-enterprise cooperative innovative teaching model, the average score increased to 80 points. Specifically, in terms of robot path planning accuracy, the average score for students in the traditional teaching model was 50 points, which increased to 75 points under the innovative teaching model; in terms of handling efficiency, the average score for students in the traditional teaching model was 40 points, which increased to 65 points under the innovative teaching model. These data clearly demonstrate the significant improvement in the quality of students' project outcomes through the school-enterprise cooperative innovative teaching model.

5.4. Improve Students' Comprehensive Abilities Through Innovative Means

Improvement of practical ability: Through school-enterprise cooperation, students can apply the knowledge they have learned in actual projects and gain more practical operation experience. In the enterprise training base, students participate in tasks such as automated production line debugging, robot programming, and troubleshooting, which greatly improves their practical ability. Compared with the traditional teaching model, students' operating skills and engineering practice experience in this environment are more directly exercised.

Cultivation of innovative thinking: Project-based teaching requires students to propose innovative solutions when solving practical problems. Through interaction with enterprise mentors, students can be exposed to cutting-edge technologies and industry challenges, and stimulate innovative thinking when facing practical engineering problems. For example, in the intelligent manufacturing project, students need to design an intelligent production line scheduling algorithm, which requires not only the students' engineering and technical capabilities, but also their ability to think innovatively and apply technology.

Improvement of teamwork ability: Mechatronics projects usually require interdisciplinary cooperation. In these projects, students need to work with team members from different backgrounds to solve technical problems in the project. This opportunity for interdisciplinary cooperation enables students to improve their teamwork ability in the process of problem solving, learn to divide the work and cooperate in the team, and achieve common goals.

5.5. Evaluation of Practical Training Effect

In order to evaluate the learning effect of students in mechatronics practical training, a variety of evaluation methods are adopted, including questionnaires, interviews, results display and comparative analysis. The following are the specific implementation and results of these evaluation methods.

(1) Questionnaire survey

After the practical training course of each semester, the school will conduct a questionnaire survey on students to collect students' feedback on practical training content, teacher guidance, teaching facilities and cooperative enterprises. The questionnaire mainly covers the following aspects:

Practicality of teaching content: Most students believe that the project courses brought by school-enterprise cooperation can better meet market demand, and the technology learned is more in line with the forefront of the industry, which improves their employment competitiveness.

Opportunities for practical operation: Most students said that through the actual projects provided by the enterprise, they have more opportunities for practical operation, which is closer to the real engineering environment than traditional classroom learning.

Teamwork and communication: Students generally believe that through the cooperation of team projects, they have learned how to divide the work and cooperate in the team, and learned a lot of teamwork skills, especially when solving practical engineering problems, the importance of teamwork ability is becoming more and more prominent.

(2) Interviews and tutor feedback

Through interviews with students and enterprise tutors, we further understand the performance and gains of students in the practical training process. Many enterprise tutors said that students showed a strong sense of innovation and independent problem-solving ability during the implementation of the project. They were able to propose reasonable technical solutions during the guidance process and quickly implement them into the project. After the completion of the practical training, some students were also hired or recommended by the enterprise, which reflects the success of the practical training effect.

(3) Results display

Every semester, the school will organize a practical training results display activity, and students need to show the project results they participated in to teachers, students and enterprise representatives. The display content usually includes the project design, implementation process, innovation points and technical application of the project in which the students participated. The display activity not only promotes the students' results display and self-reflection, but also provides enterprises with an opportunity to understand the students' innovative results. Many enterprise representatives highly praised the students' performance and expressed their willingness to further deepen cooperation.

(4) Comparison between traditional teaching mode and innovative teaching mode

By comparing with students under the traditional teaching mode, the results show that under the innovative teaching mode (such as project-based learning, flipped classroom, virtual simulation and practical operation), students have shown obvious advantages in the following aspects:

Practical ability: Compared with students under the traditional teaching mode, students under the innovative teaching mode have significantly improved their practical ability in project implementation, equipment operation and engineering commissioning. Through real projects provided by enterprises, students can apply theoretical knowledge to practice and gain more practical experience.

Innovative thinking: Under the innovative teaching mode, students' innovative thinking is better cultivated (Zhu et al., 2019; Zhu & Zhang, 2021). Due to the characteristics of project-driven learning, when students face practical engineering problems, they must not only apply existing knowledge, but also constantly seek innovative solutions. This model encourages students to shift from theory to practice and strengthens their innovation ability.

Teamwork ability: Project-based teaching emphasizes students' teamwork and multidisciplinary collaboration ability. In the process of completing projects with team members, students learn how to divide work and cooperate, and how to solve problems in teamwork. This ability is particularly prominent under the innovative teaching model.

6. Conclusions

This paper provides an in-depth analysis of the current status, challenges, and innovation paths of mechatronics education by examining the integration of practical teaching resources and innovative practices under the framework of New Engineering. It highlights the limitations of traditional teaching models in addressing the evolving demands of industry and explores how integrated resource allocation and innovative teaching strategies can bridge this gap. Through the comprehensive integration of hardware, software, human resources, and case-based content—facilitated by school-enterprise cooperation, the introduction of social resources, and the application of intelligent technologies—a more robust and dynamic learning platform has been constructed.

In terms of educational innovation, this study demonstrates how the combination of project-based learning (PBL), flipped classrooms, virtual simulation, and hands-on practice—along with deep collaboration between academia and industry—enhances students' practical abilities, innovative thinking, and interdisciplinary problem-solving skills. Case analyses further validate the effectiveness of these strategies, particularly in strengthening students' operational skills, creativity, and teamwork under school-enterprise collaborative models. Additionally, evaluation methods such as surveys, interviews, and performance assessments provide valuable feedback and data-driven support for continuously optimizing practical training.

Looking ahead, as technologies like artificial intelligence, the Internet of Things, and big data continue to evolve, mechatronics education is poised for transformative growth. Future directions should emphasize intelligent, personalized, and diversified teaching practices. Specifically, the following areas warrant focused attention:

Intelligent Teaching and Personalized Learning:
Leveraging AI and big data analytics, future teaching can be tailored to individual learning needs. Intelligent platforms will enable teachers to customize learning paths, while AI tutoring systems provide real-time feedback and adaptive instructional strategies.

Integration of Virtual and Augmented Reality Technologies:
The incorporation of VR and AR will offer immersive training environments where students can interact with complex mechanical and automation systems virtually—enhancing skill acquisition while minimizing risk and resource consumption.

Interdisciplinary Integration and Innovation Platforms:
As the industry moves toward digital and intelligent manufacturing, education must promote cross-disciplinary collaboration. Schools should build open innovation platforms that integrate engineering, computer science, AI, and other domains to foster practical, interdisciplinary project work.

Enhanced School-Enterprise Collaboration and Optimized Resource Integration:
Deeper and broader school-enterprise partnerships will be crucial for aligning educational content with real-world industry needs. Collaborative curriculum development, updated teaching materials, and internship opportunities will enhance students' employability and adaptability.

Integrated Development of Industry, Academia, Research, and Application:
Beyond enterprise cooperation, schools should also work closely with research institutions to co-develop cutting-edge technologies and innovations. Participation in real-world R&D projects will enrich students' practical experience and ensure a virtuous cycle between theoretical learning and practical application.

In conclusion, under the guidance of New Engineering, mechatronics education must continue evolving through intelligent, technology-driven, and industry-integrated approaches. These efforts are essential to cultivating high-quality, innovative engineering talents capable of meeting the complex demands of modern and future industrial development.

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