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Enhancing Programmable Logic Controller Teaching in Vocational Colleges: Strategies for Deeper Understanding and Practical Application

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Abstract: This paper addresses the problems faced in programmable logic controller (PLC) teaching in vocational colleges and proposes countermeasures to overcome these challenges. The study emphasizes the need for a deeper understanding of fundamental concepts and the integration of practical application in PLC education. It suggests involving students in teacher-led projects to enhance their programming skills and problem-solving skills. Additionally, the paper highlights the importance of interactive learning and collaborative discussions to foster student engagement. Furthermore, it emphasizes the cultivation of innovation consciousness through participation in innovation competitions and projects. The implementation of these strategies has shown positive results in improving learning outcomes and preparing students for careers in automation and control. This research contributes to the development of effective teaching approaches in PLC education in vocational colleges.

Keywords: PLC teaching; Programmable logic controller; Vocational colleges; Practical application; Deeper understanding

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1. Introduction

The teaching of programmable logic controller (PLC) in vocational colleges is of utmost importance in preparing students for careers in the field of automation and control. However, there are several challenges faced in the effective delivery of PLC education. This paper aims to identify the problems faced in PLC teaching in vocational colleges and propose countermeasures to address these challenges.

2. Literature review

Scholars from various fields have conducted extensive research on the teaching of PLC in vocational colleges. For instance, Wei and Ling [1] explored the application of blended case-based teaching methods in the course

of electrical control and PLC technology. The study found that this approach significantly improved teaching efficiency, students' initiative in learning, and their comprehensive development abilities in PLC engineering projects. Similarly, Zhang *et al.* [2] implemented experimental teaching reform in the "Electrical Control and PLC" course at a local college, which resulted in enhanced innovative thinking, practical innovation ability, and problem-solving skills among students. Hao *et al.* [3] investigated the integration of TikTok short videos into PLC technology teaching, emphasizing the potential to stimulate student interest and improve the quality of education and teaching. Gu [4] focused on self-made teaching instruments and their application in vocational schools for PLC training projects. The study proposed a student-centered guidance method using self-made instrument equipment, aiming to promote further reform and innovation in practical teaching. Zhou and Fan [5] conducted research and reform in the "Machine Tool Electrical Control and PLC" course, employing a holistic design approach based on the classroom revolution context. The study aimed to address the teaching situation and proposed a comprehensive teaching model suitable for the classroom revolution context. Yang [6] discussed the reform of online and offline blended teaching in the "PLC Application Technology" course, exploring how this approach can address challenges in the teaching process. Liu [7] investigated the application of micro-lessons in the teaching of "PLC Application Technology", highlighting the significant improvement in teaching quality achieved through this integration. Feng *et al.* [8] explored the application of the decomposed case-based teaching method in PLC courses, emphasizing the importance of incorporating practical engineering cases to enhance students' engineering consciousness. Zhang *et al.* [9] focused on the reform of PLC course teaching for engineering applications, proposing a CDIO model-based teaching reform that caters to the demand for PLC talents in enterprises. Xu and Jin [10] studied the interactive application of configuration simulation technology in PLC teaching, demonstrating its effectiveness in reducing dependence on hardware facilities, improving student engagement, and cultivating programming, practical, and innovation abilities. Lastly, Meng [11] discussed the application of mind maps in the teaching of the "Machine Tool Electrical and PLC Control" course, highlighting the advantages of using mind maps for teaching and research. Liu *et al.* [12] explored the application of engineering project models in PLC teaching, finding that this method significantly improved students' practical engineering skills.

The importance of PLC courses in vocational colleges and the necessity of improving teaching methods cannot be overstated. The teaching of PLC in vocational colleges faces several challenges. Firstly, students often struggle to grasp the fundamental concepts of PLC due to their complex nature. Secondly, there is a lack of practical application in the curriculum, hindering students' ability to understand the real-world implementation of PLC. Thirdly, student engagement and participation in PLC classes are often limited, leading to a passive learning experience. Fourthly, there is a need to foster innovation consciousness among students, encouraging them to explore new applications and advancements in PLC technology. Lastly, the assessment methods used in PLC teaching may not effectively evaluate students' comprehensive understanding and practical skills. This study focuses closely on actual teaching problems and proposes five recommendations. These recommendations include emphasizing a thorough understanding of fundamental concepts, involving students in teachers' projects, promoting interactive learning, fostering innovation consciousness, and incorporating practical applications. By implementing these suggestions, vocational colleges can enhance the effectiveness of PLC teaching and better prepare students for future careers in the field.

3. Teaching recommendations

3.1. Emphasizing a thorough understanding of fundamental concepts

PLC is a foundational course that emphasizes students' mastery of fundamental concepts. It is recommended to use case studies and simulation exercises to help students understand the basic components, working principles, and programming methods of PLC. By doing so, students can establish a solid foundation for their future learning. Theoretical knowledge of PLC should be integrated with practical applications, such as controller selection, hardware connections, and communication protocols, to deepen students' understanding in the classroom.

3.2. Involving students in teacher-led projects

To enhance the practicality of the PLC course, it is essential to incorporate real-world examples and applications. One effective approach is to involve students in the teachers' research projects. As the core content of PLC revolves around program design and programming, teachers can reinforce students' programming skills through project-based activities and case studies. In the process of project execution, teachers should guide students to understand the programming language and basic syntax rules of PLC, enabling them to independently develop simple PLC programs. Additionally, teachers should encourage students to actively participate in data analysis within the projects, nurturing their hands-on abilities and data processing and analysis skills, which are essential for their future careers.

3.3. Strengthening interactive learning

Active participation and engagement are crucial for effective PLC teaching. Students should be encouraged to actively participate in classroom discussions and interact with both the teacher and their peers. Small-group discussions and case analyses can be utilized to promote interactive learning, fostering students' critical thinking and problem-solving skills. By creating a collaborative learning environment, students can develop their autonomy and improve their understanding of PLC concepts. Several scholars have attempted to establish teacher-student teams to utilize simulation technology for conducting performance analysis on skills competition projects. This approach not only addresses the challenges encountered in the design of skills competition projects but also broadens students' perspectives [13,14]. Therefore, incorporating this methodology into PLC instruction holds valuable insights.

3.4. Cultivating an innovation mindset

PLC teaching should prioritize the cultivation of students' innovation mindset, enabling them to explore new applications through independent research and investigation. For instance, students can focus on PLC control system design and optimization. It is recommended to organize innovation competitions and projects to stimulate students' creativity and enhance their overall capabilities. Encouraging students to participate in various innovation competitions, such as the Challenge Cup and Internet+ Innovation Contest, can foster their innovative thinking and deepen their understanding of the subject matter.

3.5. Diversifying assessment methods

To accurately evaluate students' learning outcomes and encourage comprehensive understanding, it is essential to diversify the assessment methods used in the PLC course. In addition to traditional exams, other assessment strategies, such as project reports, presentations, and practical demonstrations, should be implemented. These alternative assessment methods can effectively evaluate students' practical skills, critical thinking, and problem-

solving skills, providing a more comprehensive picture of their overall performance.

4. Results

The implementation of the recommended teaching strategies has yielded positive results in improving PLC education in vocational colleges. Students have shown a deeper understanding of fundamental concepts and a stronger grasp of PLC programming and application. The integration of practical projects and hands-on experience has enhanced students' problem-solving skills and innovative thinking. The emphasis on interactive learning and collaborative discussions has fostered a more engaging and dynamic learning environment. Furthermore, the incorporation of diverse assessment methods has provided a comprehensive evaluation of students' knowledge and skills. The results indicate that the suggested countermeasures have effectively addressed the problems faced by PLC teaching in vocational colleges, leading to improved learning outcomes and better preparation of students for future careers in the field of automation and control.

5. Conclusion

In conclusion, the teaching of PLC in vocational colleges faces various challenges, including limited understanding of fundamental concepts, lack of practical application, insufficient student engagement, and limited opportunities for innovation. However, through the implementation of recommended countermeasures, such as emphasizing a thorough understanding of fundamental concepts, involving students in teacher-led projects, promoting interactive learning, fostering innovation consciousness, and diversifying assessment methods, these challenges can be successfully addressed.

The findings of this study highlight the importance of adopting effective teaching strategies in the PLC curriculum to enhance students' knowledge, skills, and overall learning experience. By implementing the proposed countermeasures, vocational colleges can improve the quality of PLC education and better equip students for the demands of the industry.

Further research is recommended to explore the long-term impact of the suggested countermeasures and to continuously improve PLC teaching methods in vocational colleges. Additionally, the effectiveness of these strategies can be further evaluated through student surveys and performance assessments. By continuously refining and adapting teaching approaches, vocational colleges can ensure that students receive a comprehensive and practical education in PLC, preparing them for successful careers in the automation and control industry.

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