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Exploration and Practice of Discipline Competition-Driven Practical Ability Cultivation for Engineering Students in the Context of Engineering Certification: Taking the Internet of Things Engineering Major as an Example

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Abstract

Discipline competitions can have a positive impact on the learning potential of students, as well as on their skills and innovation abilities. They are particularly effective in cultivating the engineering practice abilities of applied undergraduate students, which is of vital significance. This paper takes the Internet of Things (IoT) engineering major as an example to explore ways to cultivate the independent innovative consciousness, thinking, and skills of students, as well as to improve the overall quality of students. Key aspects such as the practice system of disciplinary competition, practice management and organisation strategy as well as the practice project development system are thoroughly researched and discussed, aiming to provide experiences that can be used and referred to for the cultivation of engineering talents.

Keywords

Discipline Competition, Talent Training, Innovation Ability, Engineering Education Accreditation

1. Introduction

The construction of first-class undergraduate major points now requires higher levels of innovation ability from engineering undergraduates. The General Standards for Accreditation of Engineering Education (revised in November 2017) by the China Association for Accreditation of Engineering Education Professions has made specific provisions in this regard. The standard includes 12 pro-

visions for students to achieve the knowledge, skills, and literacy required for graduation. Eight of these provisions are specifically aimed at solving complex engineering problems (Han & Zhang, 2021). This facilitates effective communication and exchange with industry peers and the public regarding complex engineering problems. The university serves as a social source of talent, providing the community with appropriate professionals according to their needs. Starting from the needs and the positioning of the computer science, our aim is to develop the creativity of the students and to improve their overall quality. We will strengthen the cultivation of practical skills, stimulate enthusiasm for learning and innovation, and encourage the development of individuality. Combined with the characteristics of undergraduate education in the new engineering professional disciplines, we aim to enhance the innovation ability of college students (Ma et al., 2021). To achieve this, we propose practical measures suitable for engineering colleges. To achieve these goals, we must innovate the management system for cultivating the innovation ability of engineering undergraduates, improve the level of innovation ability cultivation in the construction of first-class majors, and enhance the innovation mechanism of collaborative education and training between industries, universities, and research institutes. This will comprehensively improve the level of human education.

2. Significance of the Subject Research

In 2018, General Secretary Xi Jinping delivered an important speech at the National Education Conference, emphasizing that "education should be made to enhance students' comprehensive quality, educate and guide students to cultivate comprehensive ability and cultivate innovative thinking" (Yin et al., 2022). At present, a new round of technological and industrial reform is being carried out rapidly all over the country, and the competition is becoming increasingly fierce (Sun et al., 2023). In this process, a large number of compound talents with innovative and practical ability are needed. Starting from the needs and the positioning of the computer science, our aim is to develop the creativity of the students and to improve their overall quality. Since February 2017, the Ministry of Education has actively promoted the construction of new engineering projects to promote the development of the new economy and build a strong country in science and technology (Qiu & Wu, 2020). However, at present, there are some general problems in cultivating students' innovative and practical abilities. For example, the phenomenon of separating theory and practice exists in some schools, especially in the teaching process of teacher training colleges and universities (Shi, 2023). Some schools emphasize theory over practice, with relatively little practical training, leading to asymmetrical and unbalanced short boards in the employment process of engineering college students, who generally have a weak sense of innovation, insufficient practical ability, insufficient professional knowledge, and weak ability to solve complex engineering problems (Chen et al., 2020; Goulart et al., 2022). In view of this series of problems, the effective plan is

to reform and optimize the practical teaching innovation system. For engineering students, they are future engineering and technical talents. Innovative education can not only be realized through theoretical explanation and one-way implementation, but also needs to combine in-class theoretical knowledge learning and extracurricular practical activities. The cultivation of engineering students' innovation ability is closely related to the discipline competition, and they promote each other and provide comprehensive development opportunities for students (Liu et al., 2021).

Academic competitions provide engineering students with the opportunity to apply theoretical knowledge to practical problem solving. By participating in competitions, students are able to apply their knowledge in real engineering situations, thus enhancing their practical skills and problem-solving abilities. Academic competitions often require students to face complex engineering problems, which motivates them to develop innovative thinking and approaches. Solving challenges in competitions requires students to think out of the box and come up with novel solutions, which fosters their sense of innovation and creativity.

Subject competitions are often conducted in team form, which helps to cultivate students to play their respective advantages in collaboration and enhance the ability of effective communication and cooperation. These experiences of teamwork are critical to practical work in the engineering field. Subject competitions usually set up real and challenging problems, which require students to solve them by comprehensively using all kinds of knowledge. This helps to cultivate engineering students' ability to think independently and solve practical engineering problems. Subject competitions often involve practical project development, and participants need to apply theoretical knowledge to the project. This provides students with valuable practical experience to better understand and apply the engineering skills learned. The topics and requirements of subject competitions are often closely linked to the needs of the industry. By participating in the competition, students can better understand and adapt to the actual requirements of the engineering field and improve their competitiveness in future employment. Discipline competition provides a platform for engineering students to comprehensively exercise and show their ability, and is an important way to cultivate innovation, practice and teamwork ability (Agrawal & Harrington-Hurd, 2016; Huang et al., 2022).

3. Research Content

3.1. Practical Concept Innovation Based on Innovation

In the face of the new situation and new requirements of the construction of first-class undergraduate specialty points, the adjustment and innovation of the management mechanism has become a key guarantee for a university to successfully cultivate high-quality innovative talents (Qiu, 2021). In order to meet the needs of the construction of new engineering disciplines and the cultivation of excellent talents, Yancheng Teachers College actively carries out the explora-

tion of college students' innovative team construction, and the practice shows that disciplinary competitions are an important way as a way for students to improve themselves and cultivate their innovative ability, which is of great significance for colleges and universities to cultivate high-quality and innovative talents in the new era. The university unites the strengths of instructors, majors, colleges, the Academic Affairs Office, the Youth League Committee and other departments as well as relevant teachers. From the system level, the responsibilities of the focal management department (e.g., Academic Affairs Office)-business departments (colleges, majors)-participating project teams (participating students and instructors) are clearly defined in the management system. In this way, it can form the motivation to cultivate the innovation ability of college students from within, establish the consciousness of continuous improvement and striving for the first-class, and promote the spirit of unity, sharing and common prosperity. At the same time, our university actively carries out school-enterprise cooperation and collaborative education mechanism. Focusing on the development of strategic emerging industries and technologies of big data and artificial intelligence, the university and enterprises are committed to cultivating innovative and application-oriented talents. In August 2016, the School of Information Engineering became one of the first batch of institutions to cooperate with Data China's "Hundred Schools Project", and in November 2018, the "Hundred Schools Project" project "Collaborative Innovation Platform for Big Data Application" jointly constructed by the university and enterprises passed the project acceptance by experts from the Ministry of Education. Innovation Platform for Big Data Application" passed the acceptance of experts from the Ministry of Education. In addition, our university integrates innovation education in teaching practice, combining theoretical knowledge and practical operation in order to enhance students' engineering ability and comprehensive quality, and pushes innovation education to all students, integrates it into professional education, and incorporates it into the whole process of talent cultivation, as an important content to improve the quality of talent cultivation.

3.2. Innovation of Practice System Based on Discipline Competition

With the main line of applied practical innovation ability, we organically combine the competition program with the curriculum, aiming to build an interdisciplinary competition knowledge system for students. In this teaching system, we are committed to solving complex engineering problems as a task, so as to promote students to achieve deep understanding and practical application of knowledge. At the level of engineering ability cultivation, we have constructed a multi-level practical teaching system, covering different levels, such as "project conceptualization level, engineering design level, project implementation level and project operation level", so as to comprehensively cultivate students' engineering ability. First of all, we emphasize the close integration of the competition projects with the curriculum to ensure that students can apply what they have

learned in real problems during the learning process. This close integration helps students to combine theoretical knowledge with practical application, thus improving their problem solving ability. By setting tasks to solve complex engineering problems, we encourage students to apply what they have learned in real-world operations and develop their independent thinking and problem-solving skills. At the knowledge level, we are committed to building an interdisciplinary knowledge system for the competition, so that students can cross different fields in the competition program and gain a comprehensive knowledge base. This helps to develop students' comprehensive literacy and make them more competitive in their future career fields. At the same time, through the multidisciplinary knowledge system, we are also able to cultivate students' teamwork ability, so that they can better cooperate with different professionals in real projects. At the level of engineering ability cultivation, our practical teaching system is divided into different levels, i.e. "project conceptualization level, engineering design level, project implementation level and project operation level". This multilevel structure aims to enhance students' engineering competence in a comprehensive way, from project conceptualization to implementation and operation, throughout the entire engineering life cycle. This approach helps students to develop a holistic view of the actual project, focusing not only on technical details, but also on the feasibility and sustainability of the project as a whole. The phased implementation of the competition project is an important part of our practical teaching. Each phase corresponds to a specific graduation requirement indicator, ensuring that students are able to meet the relevant graduation requirements during the practical process of the project. Through this organized process, we aim to develop students' engineering competence to enable them to independently solve and respond to complex engineering problems in their future careers.

4. Methods of Engineering Talent Training Based on Discipline Competition

Academic competitions are an important part of practical teaching in universities, an important step in the reform of innovative education, an important platform for enhancing the innovative ability of college students, an effective way for students to flexibly apply what they have learned in practice, an effective means to stimulate students' interest in learning, exercise their creative thinking and improve their comprehensive quality. The problems reflected in the competition process are fed back to the teaching process in time, forming a teaching community of teachers and students linkage and symbiotic development, enhancing students' creativity, thinking and action, and forming a tripartite linkage of faculty-professionals-teachers and students to the innovative activities of the nurturing mechanism, whose general idea is shown in **Figure 1** below.

Under the guidance of the concept of "student-centered and outcome-oriented" professional accreditation of engineering education, we have carried out an

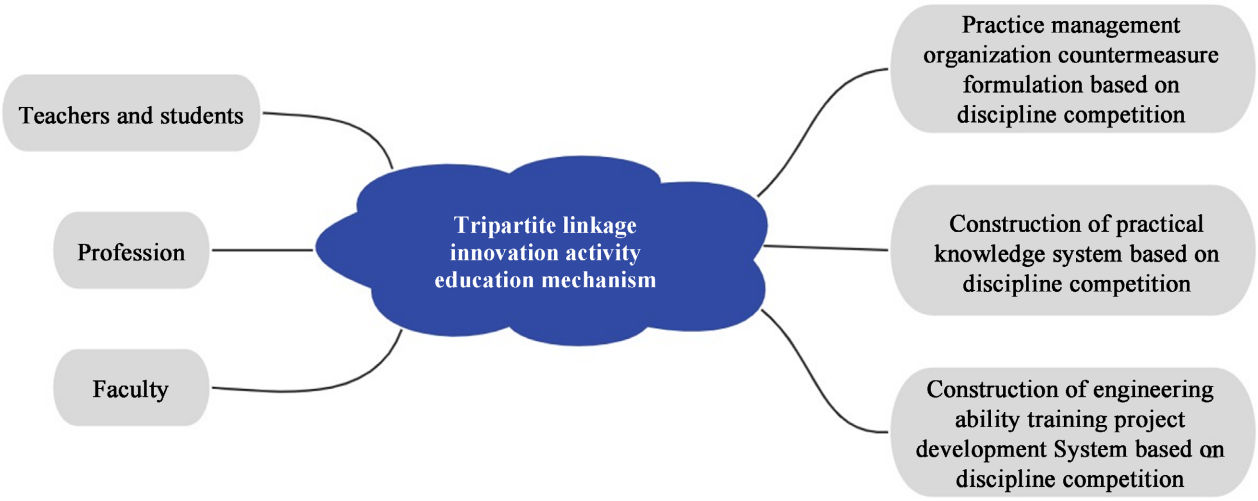

Figure 1. Faculty-professional-teacher-student tripartite linkage mechanism of innovative activities to educate people.

in-depth reform of the IoT engineering curriculum (Huang et al., 2023). The training objectives are designed as a hierarchical structure to ensure that students can gradually master and deepen their knowledge, and at the same time, they can make adjustments according to their own progress. The practical teaching sessions and disciplinary competitions are also carefully designed as a laddered package, so that students can continuously improve themselves in practice and also have the opportunity to show their strength in the competition. In addition, the leading position of students should be emphasized in the process of practical teaching, and they should be encouraged to actively participate and take the initiative to explore, so as to ensure that students have enough time for self-learning and thinking, and also to benefit from collective discussions. As for the effect of practical teaching, what should be emphasized is the process evaluation, not just the final result. It is only through a comprehensive process of assessment that we can truly understand the learning of our students and provide them with the most appropriate guidance and support. In general, the reform of IoT engineering curriculum has important practical significance and theoretical value in the context of professional certification of engineering education. It enhances the engineering skills of the students and provides them with a solid foundation for their future development.

4.1. Formulation of Practice Management Organization Countermeasures Based on Discipline Competition

1) Enhancing funding input to meet competition needs

By increasing the capital input, we can use it to reward excellent players, train instructors, buy competition equipment and promote the competition. This will motivate more excellent contestants to participate in the competition, improve the organization and guidance ability of teachers, enhance the practical skills of students, and increase the popularity and influence of the competition, so as to achieve the goal of improving the level of the competition and enhancing the

performance of students in the competition.

2) Increase publicity and improve the incentive mechanism

Before registration for various competitions begins, in addition to traditional publicity methods such as posters and QQ groups, social media, campus radio, the school website and other channels are utilized to widely convey information about the competitions and attract more students' attention. In addition to publicizing the competition before registration, relevant lectures, sharing sessions or mini-competition events were held to let students experience the fun and challenges of the competition in advance, thus arousing their interest and desire to participate. In addition to publicity, an incentive mechanism has also been established to reward those students who perform well in the competitions, so as to better promote their learning motivation.

3) Optimize the competition process and enrich the competition forms

By optimizing the competition process and adding new competition forms, the enthusiasm of students to participate in the competition and the competition results can be further improved. Optimizing the competition process can improve the efficiency and fairness of the competition and reduce unnecessary waste of resources; while rich competition forms can attract more students to participate and stimulate their innovative spirit.

4.2. Construction of Practical Teaching Concept Based on Subject Competition

Discipline competitions, as a kind of exploratory engineering practice activities, stimulate students' learning interest and innovation spirit with its goal of solving complex engineering problems. Participants need to synthesize the knowledge of multiple disciplines to solve problems, so it is crucial to reasonably construct the knowledge system of the competition. In the process of practical teaching, we actively advocate teamwork. By participating in the competition together, students can not only exercise their professional skills, but also learn how to communicate and coordinate with others, and develop a good teamwork spirit. The teaching method driven by discipline competition is a new education mode aiming at cultivating students' ability to solve complex engineering problems. This approach is especially suitable for students majoring in computer science, and helps to improve their ability to solve complex engineering problems and their innovative and practical abilities in the context of the current professional accreditation of engineering education. By participating in disciplinary competitions, students can learn in practice and grow in challenges, so that they can better understand and master their professional knowledge and apply this knowledge to practical problems. This not only helps to enhance their professionalism, but also develops their innovative thinking and critical thinking ability. As an innovative and practical teaching method, academic competitions play an important role in promoting the comprehensive quality of students.

4.3. Construction of Project Development System for Engineering Ability Training Based on Discipline Competition

The project development system construction consists of four main phases: project conceptualization phase, project engineering design phase, project implementation phase, and project operation phase. The whole project relies on students and teachers, so in the process of this project system construction, the project will be discussed around these two roles, as shown in Figure 2.

1) Project Conception Stage

During the project conceptualization phase, the instructor will first teach the course design with the competition project as the main component. This is a very important process because it is the starting point of the whole project cycle and has a profound impact on the subsequent design and implementation. Initially, the instructor will guide students to select a project in groups. In this process, students need to complete a series of research work, including searching for relevant literature, understanding the progress of similar projects at home and abroad, and analyzing the feasibility of the selected project in depth. Through these research activities, students can better understand the background and needs of the project and prepare for the subsequent work. After completing the preliminary research, it is necessary to conduct an in-depth analysis of the project requirements and write a project feasibility report. This report not only contains the background information of the project and the technical specifications required, but also elaborates on the project's objectives, expected outcomes, and the problems and challenges that may be encountered.

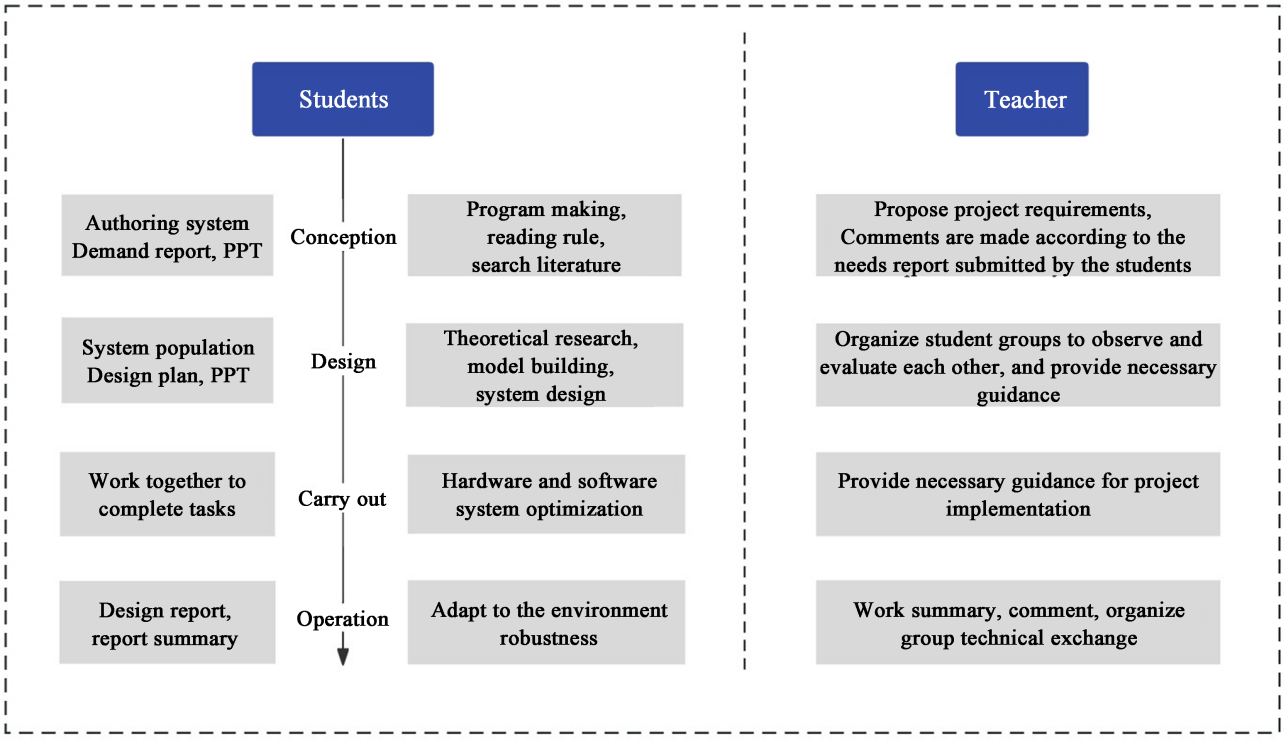

Figure 2. Faculty-professional-teacher-student tripartite linkage mechanism of innovative activities to educate people.

This is the core content of the project conceptualization stage, which is decisive for determining the direction and objectives of the project. Next, the instructor leads all students in a group observation to raise possible problems with the project and discuss solutions together. This approach can help students improve their teamwork and enhance their problem-solving skills, as well as improve their communication skills and critical thinking abilities. Finally, the teacher will guide students to further improve the project requirements analysis report to ensure that it comprehensively and accurately reflects the actual needs of the project. This process not only helps deepen students' understanding of the project, but also lays a solid foundation for subsequent engineering design and implementation. The project conceptualization phase is a process full of challenges and opportunities. By participating in this stage of learning and practice, students can not only improve their professional skills, but also develop a good team spirit and a sense of innovation, laying a solid foundation for their future careers.

2) Project Engineering, Design Stage

For students participating in the competition for the first time, in the project engineering design stage, it is often based on the system framework provided by the instructor, who guides the students to conduct relevant literature review, and repeatedly discusses the design of a general program that meets the actual engineering project. The program should meet the various functional requirements set forth in the project requirements and specify the performance indicators to be achieved by the system. In the design process, also take into account the future update of equipment, control objects, such as the increase or decrease of the problem, in order to facilitate the development of functional expansion. We recommend the use of hardware modular and software modular building block structure, so that it can be flexibly expanded according to different control requirements. In the overall design program, it should include the design of the control algorithm in the system, the hardware schematic diagram and software block diagram of the system, and write a detailed design description document. The instructor should organize all students together to demonstrate and review the scheme.

3) Phase of the Project Implementation

At the initial stage of project implementation, the project team leader can apply for the college's innovation laboratory as a fixed place for project development. In the process of implementation, the group is in the mode of division of labor and cooperation, to ensure that each member of the group has a clear and specific task requirement, while the project team must comply with the relevant provisions of the laboratory management. During this period, the group leader organizes group members to conduct at least 2 hours of intra-group discussions per week, and the instructor organizes seminars based on the actual problems and results of the project implementation process. RFID access control system project, for example, mainly includes six steps: a) Understanding the project process, mainly includes the basic theory involving RFID, control algorithms, etc.; b) Determine the overall design framework of the system; c) System struc-

ture design; d) Hardware Circuit Design and Implementation: Complete the design of the project's required hardware circuitry principles, including the data acquisition module, storage module, display module, door control module, alarm module, Keyboard module and the design of the host computer software in several aspects; e) software program design and debugging, including the software code for RFID access control module design and debugging with hardware, with the host computer software for analysis; f) system design and system tuning, build a simulation site, the modules will be debugged jointly to test the relevant functions.

4) Operation Phase of the Project

During the commissioning and operation phase, our project design is almost complete. However, in order to simulate the actual engineering practice, we also need to verify the reliability of the project implementation. This is not only to ensure the successful implementation of the project, but also to improve the practical ability of students. During the competition, we will add some disturbing factors to the system designed by the students, such as wearing hats and other objects that obscure facial features, in order to test the stability and robustness of the system. The introduction of these interfering factors can better simulate the various complexities in the real environment, thus assessing the performance of the system in a more comprehensive way. In the face of these challenges, the project team must eliminate the external disturbing factors within a limited period of time and optimally adjust the system to meet the requirements of simulating real-world engineering applications. This is a very important process because it not only helps students understand how to deal with real-world problems, but also hones their resilience and teamwork skills. After completing all aspects of the entire project, we will organize the project team members to summarize and write a project technical report. This report will record the whole process of the project, including the problems encountered, the solutions and the final results. In addition, we will also create relevant PPTs for the project report closure so that other people can understand the results of our work. Overall, through this process, we can enable students to better understand and master the knowledge and technology of IoT engineering, and at the same time cultivate their practical ability and innovative spirit.

5. Mechanism Results

The college attaches great importance to the significance of college students' innovation in promoting the reform of talent training mode, and actively integrates innovation education into the whole talent training process. To this end, the college has strengthened the training of innovation instructor team and promoted the smooth development of all kinds of disciplinary competitions, which has achieved remarkable results. In the past three years, it has organized and hosted the Blue Bridge Cup Yancheng Competition of Jiangsu Province. Students have actively participated in various disciplinary competitions, and in the past three years, they have won one bronze prize in the national competition

of "Challenge Cup" China University Student Entrepreneurship Plan Competition, one first prize and three second prizes in China University Student Computer Design Competition, one first prize and three second prizes in U.S. University Student Mathematical Modeling Competition, one first prize and three second prizes in National University Student Information Security and Countermeasures Competition, one first prize in national competitions and one first prize in national competitions. The college has won more than 180 prizes in national competitions, which has effectively improved students' innovation ability, teamwork ability and ability to integrate multidisciplinary knowledge, and has promoted the construction of "new engineering" in the specialty. The college has successfully created a learning environment full of vitality and innovation through comprehensive innovative nurturing strategies. This environment encourages students to actively explore the unknown and dare to face challenges, and at the same time provides them with abundant practical opportunities and resources. As a result, students of the College are able to find a balance between theoretical learning and practical operation, and grow into new-age talents with both solid professional knowledge and excellent practical skills. In the future, the College will continue to uphold the concept of innovation and nurturing, deepen the reform of education and teaching, and aim at cultivating more high-quality talents who can meet the development needs of the society, and constantly explore and improve the education model, so as to further enhance the quality and influence of the College's teaching.

6. Conclusion

The practical ability cultivation system for engineering college students driven by discipline competition proposed in this paper has been scientifically reformed and improved after repeated tests and optimization during the research and practice of the subject. This system emphasizes the combination of theory and practice, aiming to stimulate students' learning interest and improve their practical operation ability and innovation ability by means of discipline competition. This unique training experience can provide valuable reference value for similar undergraduate colleges and universities, helping them to better enhance students' engineering practice ability. This model helps to break the traditional teaching mode so that students can learn through participation and grow through practice, thus more effectively cultivating applied undergraduate talents with practical operation ability and innovative spirit. The exploration and practice of practical ability cultivation of engineering undergraduates driven by disciplinary competitions proposed in this paper not only provides a sample for similar institutions to learn from, but also provides a powerful support for promoting the construction of new engineering disciplines.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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