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Competition-led: Strategy Innovation and Practical Pathways for Enhancing Students' Multidisciplinary Integration Abilities

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Abstract: The introduction of subject competitions and the implementation of multidisciplinary integration strategies constitute the core driving force behind the innovation of practical teaching in institutions of higher learning. They are also two pivotal measures in the exploration and practice of cultivating innovative talents in the field of mechanical manufacturing in Chinese universities. This paper discusses the role of competition-led initiatives in enhancing students' multidisciplinary integration abilities and how to achieve this goal through strategic innovation and practical pathways. By analyzing the positive effects of subject competitions on teaching reform, practical teaching, and the cultivation of innovative abilities, this paper proposes a new teaching reform model that integrates competitions into teaching and fosters a fusion of competition and education, aiming to promote students' comprehensive development and enhance their overall qualities.

1. Introduction

In modern society, the boundaries of knowledge have become increasingly blurred, with growing interconnections and overlaps among various disciplines. To promote students' comprehensive development, many schools have organized diverse academic competition activities. These competitions not only broaden students' horizons but also enhance their problem-solving abilities [1]. This article aims to explore the strategic innovations and practical pathways of competition-led approaches in enhancing students' multidisciplinary integration abilities. With the rapid development of technology and continuous societal progress, higher education faces unprecedented challenges and opportunities. Traditional classroom teaching models, often centered on teachers, lack opportunities for students' active participation, which largely limits the enhancement of students' innovative abilities and multidisciplinary integration abilities. To address this challenge, educational reform is imperative, and competition-led teaching strategies, as an innovative approach, are gradually becoming an important means of cultivating students' multidisciplinary integration abilities and innovative thinking. In today's society, innovative ability is regarded as the core driving force for technological progress and societal development. As the backbone of future society, college students' innovative abilities and multidisciplinary integration abilities are of great significance for the country's long-term development. However, traditional teaching methods often focus on knowledge impartation and exam-taking skills training, neglecting the cultivation of students' innovative and practical abilities. Therefore, it is particularly important to explore a teaching strategy that can stimulate students' innovative spirit and enhance their multidisciplinary integration abilities.

The competition-led strategy is proposed against this backdrop. Academic competitions represent a process of gaining a deep understanding of knowledge, systematically organizing it, and applying it in practice. With their demonstrative and guiding effects, they can effectively promote curriculum development and the reform of specialized teaching. By participating in competitions, students can apply their learned knowledge to practical problems, honing their innovative thinking and problem-solving abilities [2-3]. Additionally, competitions can stimulate students' teamwork spirit and competitive awareness, actively contributing to creating a vibrant campus atmosphere for scientific and technological innovation. This paper aims to explore the application and practical pathways of the competition-led strategy in enhancing students' multidisciplinary integration capabilities. Firstly, we will analyze the drawbacks of current traditional teaching modes and the positive effects of the competition-led strategy on enhancing students' innovative capabilities and multidisciplinary integration abilities. Secondly, we will elaborate on the specific implementation methods of the competition-led strategy, encompassing the selection of competition projects, the formation of competition teams, guidance throughout the competition process, and the transformation of competition outcomes. Lastly, through case studies, we will demonstrate the application effects of the competition-led strategy in actual teaching and summarize its significance for teaching reform and student capability development. Through this research, we hope to provide a new idea and method for the reform of higher education teaching, driving the enhancement of students' multidisciplinary integration abilities and contributing to national scientific and technological progress and social development.

2. The Role of Interdisciplinary Integration with Mechanical Manufacturing Majors Driven by Academic Competitions in Teaching Reform

Academic competitions represent a process of deep understanding, systematic organization, and practical application of knowledge. They possess demonstrative and guiding effects, effectively promoting the reform of curriculum development and specialized teaching. Academic competitions are extracurricular scientific and technological activities targeted at university students, aiming to hone their intelligence and willpower, and enhance their abilities to think independently and solve problems. In the field of mechanical manufacturing, the role of academic competitions is particularly prominent [4-5].

2.1 Stimulate Students' Innovative Thinking

In today's rapidly developing technological era, the machinery manufacturing industry is undergoing unprecedented changes. As a higher education institution that cultivates future mechanical engineers and designers, the machinery manufacturing major must keep its educational methods and content up-to-date to meet the needs of the industry. Among these, stimulating students' innovative thinking has become one of the core tasks in educational reform. As two effective teaching strategies, academic competitions and interdisciplinary integration play crucial roles in this process [6-7].

2.1.1 Academic Competitions: Catalysts for Innovative Thinking

Academic competitions, as a student-centered and practice-oriented teaching activity, provide students with a platform to showcase and challenge themselves. In the field of machinery manufacturing, various competitions such as mechanical design, robotics, and automation control emerge endlessly. These competitions not only test students' professional knowledge but also emphasize their innovative thinking and problem-solving abilities.

Firstly, academic competitions offer students real-world problem scenarios. In competitions, students are confronted with actual production needs or technical challenges, forcing them to step out of the framework of textbook knowledge and apply innovative thinking to find solutions. This practical learning approach helps students gradually cultivate the habit of innovative thinking while solving real-world problems.

Secondly, academic competitions emphasize teamwork and cross-disciplinary communication. In competitions, students need to collaborate with classmates from different majors and backgrounds to complete tasks together. This cross-disciplinary exchange provides students with a broader perspective and more sources of inspiration, helping them spark new ideas through intellectual collisions.

Lastly, academic competitions also provide students with opportunities to present their work and receive evaluations. In competitions, students' projects are examined and evaluated by experts, judges, and peers. This public evaluation mechanism not only recognizes and encourages students' innovative achievements but also exercises and enhances their innovative thinking abilities.

2.1.2 Multidisciplinary Integration: The Fertile Soil for Innovative Thinking

Multidisciplinary integration refers to the interpenetration and fusion of knowledge and methodologies from different disciplines to form new academic fields or develop new approaches for solving complex problems. In mechanical manufacturing engineering, multidisciplinary integration not only helps broaden students' knowledge base but also cultivates their innovative thinking.

Firstly, multidisciplinary integration provides students with richer knowledge resources. Mechanical manufacturing engineering itself is a field that involves multidisciplinary knowledge, such as mechanics, materials science, electronic technology, computer science, and more. Through multidisciplinary integrated teaching, students can acquire a more comprehensive knowledge background, providing abundant material and inspiration for innovative thinking.

Secondly, multidisciplinary integration aids in cultivating students' interdisciplinary thinking. When addressing complex problems, students need to utilize knowledge and methodologies from multiple disciplines for comprehensive analysis and judgment. This interdisciplinary way of thinking helps students break down disciplinary barriers, enabling the cross-border integration of knowledge and methodologies, thereby proposing more innovative solutions.

Lastly, multidisciplinary integration offers students more practical opportunities. In mechanical manufacturing engineering, students can apply their learned knowledge to solve real-world problems by participating in interdisciplinary research projects, internships, practical training, and other activities. This practical learning approach helps students deepen their understanding of multidisciplinary knowledge through practice, while simultaneously exercising their innovative thinking and problem-solving abilities.

2.2 Enhancing Team Collaboration Skills

Firstly, academic competitions play a pivotal role in the teaching of mechanical manufacturing engineering. These competitions not only test students' professional skills and knowledge but also emphasize team collaboration and problem-solving abilities. During the competitions, students need to clarify team goals and role definitions, and complete tasks through effective communication and collaboration. Such experiences can greatly enhance students' team collaboration skills and practical operation abilities. Meanwhile, academic competitions often involve complex problems encountered in actual production, which requires students not only to master theoretical knowledge but also to possess the ability to apply knowledge in practice. This teaching mode is conducive to cultivating students' innovative thinking and interdisciplinary integration abilities [8-9].

Secondly, multidisciplinary integration also plays a significant role in the teaching reform of mechanical manufacturing engineering that cannot be overlooked. With the continuous development of technology, the mechanical manufacturing industry is gradually achieving deep integration with other fields such as electronics, computer science, artificial intelligence, and more. This interdisciplinary trend requires students majoring in mechanical manufacturing engineering not only to master the knowledge of their own discipline but also to possess interdisciplinary knowledge and skills. Therefore, in the teaching process, emphasis should be placed on multidisciplinary integration, incorporating knowledge and skills from related disciplines into the teaching of mechanical manufacturing engineering. Through interdisciplinary learning and practice, students can better understand the overall operation of the mechanical manufacturing industry, improve their problem-solving abilities, and enhance their innovative thinking.

2.3 Facilitating the Integration of Theory and Practice

Academic competitions, as a unique and efficient teaching mode within the educational system, embody their core value in emphasizing the deep integration of theory and practice, providing students with a platform to closely combine classroom knowledge with practical operational skills. In the field of mechanical manufacturing engineering, academic competitions play an irreplaceable role, as they not only enable students to deepen their understanding of theoretical knowledge through practice but also significantly enhance their practical operational abilities, laying a solid foundation for their future careers.

Firstly, academic competitions, by setting specific and practical project tasks, compel students to convert abstract theoretical knowledge into problem-solving capabilities. In the field of mechanical manufacturing, theoretical knowledge often encompasses complex mechanical principles, materials science, manufacturing processes, and more. These concepts may appear obscure and difficult to understand in textbooks, but by participating in competitions, students are required to apply this knowledge in practice, such as designing mechanical structures, selecting materials, and formulating processing techniques. This process not only allows students to intuitively perceive the practical value of theoretical knowledge but also prompts them to continuously trial and error, adjust, and thereby deepen their comprehension and mastery of theoretical knowledge.

Secondly, academic competitions emphasize the cultivation of practical operational abilities, which are indispensable skills for students' future careers. In competitions, students need to personally engage in a series of tasks such as mechanical design, processing, assembly, and debugging. These practical sessions not only exercise students' hands-on abilities but also cultivate their patience, meticulousness, and sense of responsibility. Through practical operation, students can better understand the overall operational principles of mechanical systems, master the operating skills of various mechanical equipment, and lay a solid foundation for future work related to mechanical manufacturing.

Furthermore, academic competitions provide students with a stage to showcase and challenge themselves. In competitions, students face competitors from their own school, region, or even nationwide. This competitive pressure can stimulate their fighting spirit and creativity. To achieve better results, students need to continuously think, innovate, and try new design ideas and processing methods. This experience not only enhances students' professional competencies but also cultivates their innovative thinking and problem-solving abilities.

Simultaneously, academic competitions promote team collaboration and communication among students. In competitions, students typically undertake project development and implementation in teams, requiring effective communication, division of labor, and collaboration. Through team collaboration, students not only learn how to cooperate with others to solve problems together but also acquire new knowledge and skills from their teammates, achieving complementary advantages. This team collaboration experience is significant in cultivating students' teamwork spirit and leadership abilities.

Lastly, academic competitions offer students opportunities to interact with enterprises and industry experts. During the competition process, students may collaborate with enterprises for project development or invite industry experts for guidance and reviews. These experiences not only allow students to gain a deeper understanding of the latest technologies and development trends in the mechanical manufacturing industry but also provide them with valuable internship and employment opportunities. Through interactions with enterprises and industry experts, students can better plan their careers and clarify their future development directions.

3. Strategy Innovation in Enhancing Multidisciplinary Integration Capabilities through Competition in Mechanical Manufacturing Majors

3.1 Establishing a Multidisciplinary Competition Platform

By organizing knowledge competitions that integrate multiple disciplines, students are required not only to master the basic knowledge of their respective disciplines but also to flexibly apply knowledge from different disciplines. For example, a question may involve knowledge from mathematics, physics, chemistry, and other disciplines, requiring contestants to collaborate across disciplines to jointly solve the problem. Such competition formats not only test students' professional knowledge but also exercise their comprehensive application abilities.

3.2 Integrating Competition into Teaching

The core of the competition-integrated teaching model lies in "promoting teaching through competition". By organizing diverse competition activities, students' enthusiasm for learning and proactive participation can be stimulated, effectively cultivating their comprehensive abilities and innovative capabilities. For instance, the Digital Art College of Xi'an University of Posts and Telecommunications deeply integrates various design competitions into daily teaching. Through professional guidance and leadership from teachers, students are encouraged to fully engage in practical creation, transforming classroom learning into practical achievements.

3.3 Improving Competition Management and Incentive Mechanisms

Schools should formulate relevant supporting policies to enhance the work enthusiasm of laboratory teachers and encourage them to invest more effort in guiding competitions. For example, based on students' award-winning situations, corresponding reward measures can be given to guiding teachers. Special competition-related teaching reform project fund applications can be established, and incentive measures such as bonus points and subsidies in job title evaluations and appointments can be provided to award-winning guiding teachers to improve their enthusiasm for guiding competitions and promoting experimental teaching reforms.

4. Multidisciplinary Practice in the China Robot Competition and China ROBOCUP Open

Academic competitions constitute a crucial aspect of university students' practical exploration. They not only effectively stimulate the sprouting of innovative thinking, deeply tap into innovative potential, promote the shaping of innovative concepts, and achieve leapfrog progress in innovative skills, but also serve as extremely important tools for testing and enhancement. By participating in diverse academic competitions, students can intuitively test their understanding and mastery of professional knowledge. At the same time, this process provides a valuable opportunity to convert theoretical knowledge into practical operations, helping to cultivate students' comprehensive abilities to integrate professional knowledge, analyze complex problems, and find solutions. Taking the rules of robot competition projects as a benchmark, a series of detailed and specific teaching practice activity goals are carefully planned and established, which is the process of clarifying practical tasks. When formulating practical tasks, the following aspects should be comprehensively considered to ensure the effectiveness and feasibility of the tasks: competition rules and requirements, educational objectives, student ability levels, resource availability, safety, practicality, innovation, and other factors. When formulating practical tasks, practical experience from previous competitions can be used to present specific content, and targeted optimizations and adjustments can be made based on summaries of past competitions.

According to the requirements of the organizing committee, dancing robots are mainly evaluated based on three aspects: the robot's body mechanical structure, circuit control, and software design. The body mechanical structure includes finite element analysis of the main structure, stress analysis, comparison charts before and after structural optimization, new complex decorations, and innovative structures; circuit control includes partial circuit schematic diagrams, PCB diagrams, comparison charts of circuit board versions, bottom-layer motion control circuit diagrams, and basic programming frameworks; software design includes creativity and work content in human-computer interaction, speech interaction, movement design, choreography, and debugging.

The robot competition process is limited to 15 minutes, with an additional 1-minute preparation stage and 1-minute evacuation stage. At the start of the competition, team members need to place the robot in the starting area at the center of the venue and start the timer. The initial startup of the robot can be completed via a manual switch or remote control operation before placement, but from the time of self-start up to the end of the competition, the robot must operate completely autonomously. If team members come into contact with the robot during the competition, 5 points will be deducted each time. It should be noted that once the venue, props, and other competition elements are set up, team members are not allowed to make any changes or touch them.

After starting, the robot needs to complete three competition segments specified by the referee (or judge) in sequence: "Speech Recognition - Movement Performance," "Visual Recognition - Movement Performance," and "Musical Rhythm Recognition - Movement Performance." The entire process needs to be compactly conducted within 15 minutes. The content and execution order of these three segments are clearly communicated to participating teams by the referee (or judge) during the preparation stage of the competition. Specifically, the referee will announce in advance three prescribed "speech-movement" combinations and their performance order, two prescribed "visual-movement" combinations and their performance order, as well as one prescribed "music-movement" combination. Participating robots need to accurately recognize and respond to these instructions and perform the corresponding movements. Importantly, all self-selected content and movements must avoid repeating those explicitly listed in the rules. If the robot fails to complete all specified movements within 15 minutes, the performance beyond the time limit will not be counted in the final score.

4.1 Voice-Action

It consists of two parts: "command sentences" issued by team members to the robot and the "reactive actions" performed by the robot. The specified "Voice-Action" is shown in Table 1.

Table 1 Robot Voice-Action

Category	Command statement	Reaction action
Move	Forward	The robot moves forward at least 20 cm and returns to its position after completion
	Backward	The robot moves back at least 20 cm and returns to its position after completion
	Left	The robot moves at least 20 cm to the left and returns to its position after completion
	Right	The robot moves at least 20 cm to the right and returns to its position after completion
Single leg support	Left leg support	The robot changes from the two foot landing state to the state that only the left foot contacts the ground, and the other foot must leave the ground obviously for more than 2 seconds, and return to the initial state after completion.
	Right leg support	The robot changes from the two foot landing state to the state that only the right foot contacts the ground, and the other foot must leave the ground obviously for more than 2 seconds, and return to the initial state after completion.
Hang up	Raise left hand	The robot raises its left hand, holds it for more than 2 seconds, and puts it down after completion
	Raise both hands	The robot raises both hands, holds them for more than 2 seconds, and puts them down after completion
Change direction (required)	Turn right	The robot rotates at least 90 °to its right and returns to its position after completion
	Turn left	The robot rotates at least 90 °to its left and returns to its original position after completion

4.2 Vision Action

The team member shall show the action to the robot according to the action in the established table, and then the robot shall recognize these actions and execute the "action feedback" consistent with the team member's display action. The following is the prescribed "visual action" in Fig. 1.

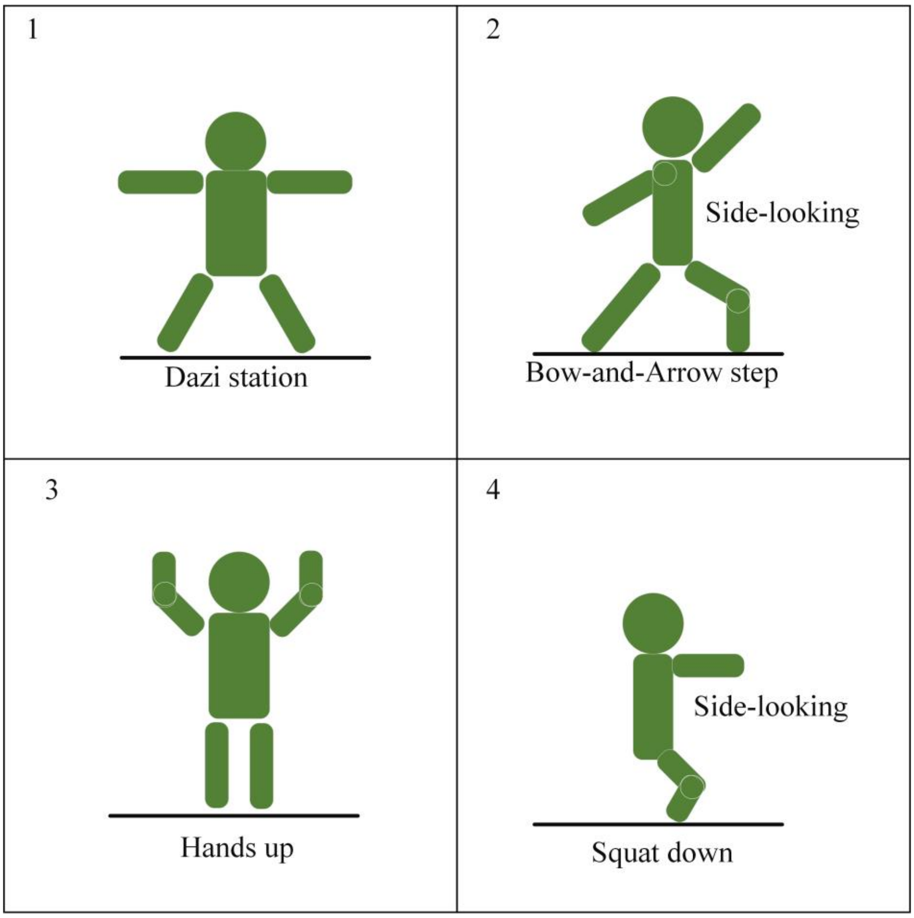

Fig. 1 The prescribed visual action

4.3 Music Action

Five pieces of prescribed music will be released within 10 days before the start of the competition for the teams to use in the debugging and preparation phase of rhythm recognition. These regulations and the music selected by the participating team shall not exceed 15 seconds each time. For the action performance of specified music, the robot needs to complete within 60 to 90 seconds, while the action performance duration of optional music needs to be controlled between 90 to 120 seconds. During the performance, the robot needs to move at least 20 cm.

The competition is the embodiment of multi-disciplinary integration. Through the integration of multi-disciplinary practice resources, it aims to deepen students' mastery of the professional knowledge, enhance their ability to analyze and solve problems by comprehensively using the knowledge of computer, electronics, automatic chemistry and other fields, and promote the improvement of team cooperation and knowledge integration ability.

5. Conclusions

Competitions play a significant role in enhancing students' multidisciplinary integration abilities. By establishing a multidisciplinary competition platform, adopting a teaching model that integrates competitions into education, and improving competition management and incentive mechanisms, we can effectively improve students' innovative and practical abilities. In the future, schools should continue to deepen the reform of the teaching model that integrates competitions into education, explore more diversified competition resources and closer curriculum integration methods, and strive to cultivate more high-quality talents with innovative spirits and practical abilities.

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