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Construction and Application of the Teaching Mode of Robot Course for Applied Undergraduate Students under the STEAM Concept

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Abstract. In the current era of rapid technological development, robot technology has become a key force driving the transformation of various industries. Applied undergraduate education shoulders the important responsibility of cultivating high-quality robot professionals who can meet the demands of industries. This study focuses on constructing a robot course teaching model based on the STEAM concept in application-oriented undergraduate colleges and conducts an in-depth exploration of its application effect, with the expectation of providing useful references for the teaching reform of related courses. Firstly, the article deeply analyzes the connotation of the STEAM concept, namely interdisciplinary integration (science, technology, engineering, art, mathematics), practical innovation and the cultivation of comprehensive quality, emphasizing its fit and importance for the teaching of robot courses. Robotics technology itself is a field that integrates multiple disciplines, covering knowledge from various aspects such as mechanical design, electronic engineering, computer programming, and sensor technology. At the same time, it also requires students to possess innovative thinking and practical abilities to solve complex problems in practical applications, which is highly consistent with the educational goals advocated by the STEAM concept. It has laid a solid theoretical foundation for the construction of the teaching mode. Secondly, the specific construction process of the teaching mode was elaborated in detail. In terms of the curriculum system, it breaks through the limitations of the traditional single-discipline curriculum setting and builds a modular curriculum system covering multi-disciplinary knowledge, such as setting up basic modules (mathematical modeling, physics and mechanics, etc.), professional core modules (robot programming, mechanical structure design, etc.), and extension modules (artificial intelligence and robots, robot art design, etc.). Enable students to systematically learn knowledge related to robots and achieve the organic integration and expansion of knowledge. In terms of teaching methods, a variety of methods such as project-based teaching, problem-oriented teaching and group cooperative learning are comprehensively applied. Take project-based teaching as an example. Teachers assign robot project tasks with practical application backgrounds, such as designing a robot for campus environment monitoring. Students need to independently consult materials, form teams, and collaborate in division of labor. They participate throughout the entire process from the overall conception of the robot, mechanical structure construction, circuit design, program writing to the final debugging and operation. This not only exercises students' practical hands-on ability, but also cultivates their comprehensive ability to solve complex problems and teamwork spirit. In the teaching evaluation link, a diversified evaluation system has been constructed. It has changed the previous evaluation method mainly based on examination scores, combined process evaluation with outcome evaluation, and focused on conducting comprehensive evaluations of students' performance during the learning process, teamwork ability, innovation ability, and the quality of project completion, etc. By observing students' performance during the project implementation process, mutual evaluation among group members, project achievement presentation and defense, etc., comprehensively and objectively evaluate students' learning outcomes, promptly identify their strengths and weaknesses, and provide a basis for subsequent teaching improvement. Finally, through the teaching practice application carried out in the robotics major of an application-oriented undergraduate college, the constructed teaching mode was verified. The practical results show that students' enthusiasm and initiative in the robot course learning have significantly increased, and their classroom participation has greatly improved. They have shifted from passively accepting knowledge in the past to actively exploring and practicing. In terms of the achievements of course projects, the robot works designed by students are more innovative and practical, and can well meet the actual application needs. For example, some intelligent logistics robots designed by students have conducted preliminary application tests in the campus express delivery sorting scenario and achieved good results. Meanwhile, the number of awards won by students in various robot competitions has also significantly increased, which fully demonstrates the improvement of students' comprehensive quality and practical innovation ability, and strongly proves the effectiveness and feasibility of the robot course teaching model based on the STEAM concept. In conclusion, the application-oriented undergraduate robot course teaching model based on the STEAM concept constructed in this study has effectively promoted students' interdisciplinary knowledge integration, practical innovation and comprehensive quality improvement by optimizing the curriculum system, innovating teaching methods and improving the teaching evaluation system. It provides new ideas and methods for the cultivation of robot professionals in application-oriented undergraduate colleges and universities. It has significant theoretical and practical significance, and can provide reference

and inspiration for the teaching reform of other related professional courses, promoting applied undergraduate education to better adapt to social development and industrial demands.

Keywords: Teaching mode, Robot course, Applied undergraduate students, STEAM concept.

1. Introduction

STEAM is an interdisciplinary education model that integrates knowledge from five major disciplines: Science, Technology, Engineering, Arts, and Mathematics. In this educational model, students solve specific problems by applying knowledge or skills from multiple disciplines, thereby achieving the organic unity of knowledge acquisition, tool usage and process innovation [1]. The 21st century is the era of educational informatization. As society gradually transitions from industrialization to informatization, it is inevitable that there will be intersections and integrations among different disciplines such as science and engineering, social sciences, humanities, and art. This will also drive the STEAM education model to gradually become a major hotspot in future education. STEAM education emphasizes the integration of knowledge from multiple disciplines. To implement the educational concept of STEAM, efforts should be focused on exploring issues such as what to teach, how to teach, what to integrate, and how to integrate. The Higher Education Department of the Ministry of Education pointed out in its report at the 11th China University Teaching Forum that courses are the core element of talent cultivation. The most direct, core and effective benefit for students from universities is courses. Courses are the ”last mile” that embodies the concept of ”student development-centered”. In the current upsurge of all-round STEAM education and teaching reform, if appropriate professional courses can be selected as effective course carriers for implementing STEAM education, and the STEAM education concept can be permeated in the specific professional course teaching practice process and the STEAM education model can be effectively integrated, it will help to exert the actual teaching efficiency of STEAM education, so as to achieve the educational goal of ”cultivating” innovative, compound and applied talents. And ”Robotics” is another important basic mathematics course for the Robotics major following Advanced mathematics, mainly used to solve related problems in the fields of science, engineering and technology. Under the trend of the ”Double First-Class” construction of higher education across the country, the creation of ”golden courses”, and the all-round reform of STEAM education and teaching, this article takes ”Robot” as the course carrier integrating STEAM education. By choosing appropriate teaching cases, this paper expounds how to purposefully attempt and extend the STEAM education concept in the teaching process of this course, with the expectation of strengthening the beneficial integration among different disciplines, demonstrating the specific teaching efficacy of STEAM education, improving the teaching quality in the classroom, and promoting the all-round development of students [2,3].

Colleges and universities are bases for cultivating advanced talents. Innovative applied talents, in addition to having a solid knowledge reserve, should also possess unique insights and innovation capabilities. They should be able to constantly identify problems, raise questions and innovate in practice, driving technological innovation. Therefore, it is particularly important to enable students to master the basic knowledge in various fields and cultivate their ability to creatively solve practical problems by comprehensively applying the knowledge they have learned. At present,STEAM education, which cultivates innovative talents through the integration of disciplines, has attracted widespread attention worldwide. The reform of STEAM education has become an important means to increase the goal of cultivating applied, compound and technical and skilled talents [4].

2. STEAM Education Concept

The core of the STEAM education concept is to break down the barriers and boundaries between traditional disciplines and achieve interdisciplinary integration. The various disciplines are not simply added together but organically integrated and restructured to form an educational whole, enhancing the smooth transfer and effective application of knowledge [5], improving students' interdisciplinary thinking ability, and enabling them to analyze and apply the inherent unity and correlation of multi-disciplinary knowledge when facing practical and complex problems, thereby solving practical problems.

Students are the main body of STEAM education. The ”student-centered” approach emphasizes that students themselves construct knowledge from within, actively integrate knowledge from various subjects, and improve, develop and enhance themselves during the learning process [6].

Carrying out STEAM education requires teachers to carefully design educational activities and organically combine independent and discrete subject knowledge to solve complex practical problems. Through teaching methods such as ”situational” and ”project-based teaching”, targeted teaching is carried out on actual problems

or projects in life to enhance students' curiosity and the interest of cognitive construction, and they learn to apply comprehensive knowledge from various subjects to solve practical problems through experiential learning. Application-oriented undergraduate colleges and universities can also integrate key domestic and international projects, critical issues and cutting-edge technologies within their professional fields to design teaching activities.

In STEAM education, learning communities have emerged by forming teams. Communication and interaction can enhance students' communication, expression and collaboration skills, fully leverage individual strengths, and also provide opportunities for brainstorming and the collision of ideas. After students complete their learning tasks, they exchange and display their achievements. Through teacher evaluation and mutual evaluation among group members, it is convenient for students to summarize experiences, make subsequent optimizations and self-improvement [7].

STEAM education can effectively help students understand the world, support them in transforming it with innovative thinking, and enhance their innovative ability and critical thinking during the learning process. Through continuous practice and exploration, high-quality innovative achievements can be derived. This is an important teaching goal of STEAM education and also one of the important ways to test the teaching results of STEAM [8].

3. Analysis of the Predicament of Teaching Reform Integrating STEAM Education

3.1. The impetus for reform is insufficient and the education system lacks top-level design

Since the introduction of STEAM education, China still lacks top-level design and specialized documents at the national level for the construction of the STEAM education system, as well as supporting mechanisms such as STEAM education quality evaluation standards and educational funding guarantees. The supply of the system is still seriously insufficient [9,10].

Deepening educational reform and innovation and resolving the predicament of the scarcity of high-quality talents in our country are the original intentions of the state in promoting STEAM education reform. However, as the specific implementers promoting educational reform, schools may oppose STEAM education or make it a mere formality due to reasons such as a shortage of STEAM teachers and insufficient support from special funds. Front-line teachers may be reluctant to participate due to increased teaching workload or a "conventional" mentality, and students may develop a resistant attitude like "experimental guinea pigs", etc., making the STEAM education reform just a slogan.

Despite the vigorous promotion of quality-oriented education and teaching reform in China in recent years, the STEAM education reform has encountered obstacles in specific practice due to the influence of the concepts of "exam-oriented education" and "education serving examinations and further education". The current education system is still outcome-oriented and emphasizes educational competition. It lacks institutional transformation and innovation based on the STEAM education concept, lagging significantly behind the establishment of the STEAM education concept. The system and the concept are disconnected from each other [11].

3.2. The Scarcity of Educational Resources Restricts the Progress of Educational Reform

Teachers are the key to the development of STEAM education. A sufficient number, qualified quality and stable team of STEAM teachers is a prerequisite for the smooth progress of the reform. However, at present, the severe shortage of professional STEAM teachers has become a common problem faced globally, especially in China, where the problem is more prominent. The number of "dual-qualified teachers" who integrate theory and practice is relatively small, and their teaching levels vary greatly [12]. Most college teachers are recent graduates with short training periods and inadequate understanding of educational theories. Most teachers themselves lack the necessary attention to innovative consciousness and innovative ability. Teachers engaged in STEAM education are not truly "STEAM teachers" in the strict sense. They do not meet the requirements that "STEAM teachers should not only possess broader disciplinary comprehensive abilities on the basis of single-subject teaching, but also be able to have both scientific and humanistic artistic qualities, as well as strong engineering design, practical operation abilities and creativity" [13].

At present, there are generally no corresponding teaching materials for STEAM education in our country. The ways to obtain STEAM teaching materials are usually self-developed by teachers or purchased by enterprises. Therefore, to promote the development of STEAM education, it is necessary to compile corresponding STEAM teaching materials, such as school-based courses and local teaching materials. In addition, the implementation of STEAM education often requires special teaching AIDS. However, the large amount of capital investment has deterred many schools. Although some schools have established corresponding STEAM laboratories, due to the neglect of research on related courses and teaching methods during product development, teachers can only teach according to the instructions, fundamentally deviating from the essence of STEAM education.

The STEAM curriculum system largely determines the quality of STEAM education and talent cultivation. At present, the STEAM curriculum system in our country has not yet been established and improved, and many schools have not included STEAM courses in their talent cultivation plans. The STEAM courses offered by schools mostly exist in the form of local courses and school-based courses. When introducing foreign STEAM courses, there is often a lack of examination of the applicability of the courses and the courses have not been ”localized”. Some schools, in an attempt to create their own characteristics, develop ”STEAM school-based courses” with the starting point of ”seeking differences”, but they lack consideration of the rationality and scientific nature of the courses. As a result, the quality of the ”specialized” STEAM courses is worrying [14].

3.3. Interdisciplinary Integration Is Weak and Educational Reform Is Merely Formalistic

Interdisciplinary integration is a typical feature of STEAM education. It attempts to guide students to adopt an interdisciplinary learning approach and form a knowledge network rather than fragmented knowledge points. For a long time, China has been restricted by traditional subject-based education. In the actual STEAM teaching, it is often simply understood as the mechanical superposition of the five major subjects, ignoring the essence of STEAM education that is problem-oriented and connects various subjects. The artificial and forced cross-disciplinary approach has led to the ”patchwork” of STEAM education content, resulting in the formalization of STEAM education. To highlight the ”interdisciplinary nature” of STEAM education, some schools have gone to the other extreme - regarding it as an independent discipline. In fact, STEAM education is merely an integrated disciplinary field. It can neither replace subject teaching nor become a new one. Disciplinizing STEAM education may promote its development in the short term, but in the long run, it destroys its development foundation and leaves STEAM education in a situation without a source [15].

4. Analysis of the Teaching Reform Path Integrating STEAM Education

Policy support provided by the state is a key force in promoting STEAM education and offers its development direction and action guidelines. The introduction of STEAM education into applied undergraduate colleges and universities must be planned and coordinated at the national level. First, strengthen top-level design and improve policies and regulations. Establish a STEAM Education research center to conduct policy research and consultation on localized STEAM education in China, and clarify the development goals, contents and paths of STEAM education at each stage of basic education and higher education. The state should strongly support all sectors of society in actively exploring, enriching and improving STEAM education policies and regulations. Second, enhance the exemplary and leading role of national-level projects, and launch some college students' innovation and entrepreneurship competitions covering multiple fields rather than being limited to a single project competition. At the same time, in terms of teacher training, assessment standards, and curriculum design, exemplary and leading roles should also be provided to gradually systematize STEAM education in application-oriented undergraduate colleges. Third, increase financial support for STEAM education. The investment of funds is the economic foundation for the integration of STEAM education into application-oriented undergraduate colleges. To provide sufficient development conditions for STEAM education, the state should improve the funding from all levels including society, schools, teachers and students, enhance the participation of all parties involved and stimulate the practical motivation [16].

STEAM education advocates project-based teaching methods. The sources of practical problems cannot be separated from companies and enterprises, official institutions, communities and social organizations. Therefore, the effective integration of STEAM education and applied talents requires support from all sectors of society. First of all, mobilize the enthusiasm of all sectors of society, enhance social participation, and involve all social stakeholders to support the management of STEAM education projects. By leveraging social resource platforms such as science and technology museums, academies of sciences, and STEAM education research centers, and in collaboration with application-oriented teacher training institutions, design STEAM education projects. Second, integrate social resources and improve the social collaboration mechanism. Since the promotion of STEAM education in China, some professional institutions and school alliances have conducted in-depth research on how to localize STEAM education. However, in terms of curriculum design, teacher evaluation and other aspects, all sectors of society have different standards. For the sustainable development of STEAM education, all sectors of society, including enterprises, communities and public institutions, should participate in establishing a cooperative mechanism to effectively integrate STEAM education into the cultivation of applied talents. Official institutions should organize STEAM education forums to bring together STEAM researchers and integrate STEAM education materials [17].

First, schools should intensify the construction of STEAM teacher teams and establish a guarantee system for the growth of STEAM teachers. First of all, emphasis should be placed on STEAM teachers enhancing their own

skills, such as interdisciplinary teaching abilities, to meet society's expectations of "versatile" teachers. Secondly, a series of measures should be taken from various aspects such as funds, technology, resources and human resources to motivate and guide the construction of the STEAM teacher team. Finally, establish a strong quality assurance system for the STEAM teaching staff. For instance, a qualification examination and regular registration system should be established for STEAM teachers to force them to enhance their professional skills and ensure that the number and quality of teachers are in line with the development level of STEAM education in various regions. Second, schools should take the STEAM curriculum reform as the entry point to establish and improve the STEAM curriculum system. First of all, clarify the basic positioning of STEAM courses. Incorporate the construction of STEAM courses into the national three-level curriculum management system and promote the standardization and institutionalization of STEAM courses. Secondly, clarifying the educational goals of STEAM courses should run through all aspects of the STEAM course reform. Secondly, build a STEAM course knowledge system based on interdisciplinary integration, and strengthen the exploration of interdisciplinary course integration models through project-driven or problem-driven methods. Finally, guide the development of STEAM education courses, actively develop school-based teaching materials suitable for the school's and students' conditions, build a platform for resource exchange and sharing, and learn from each other's strengths to offset weaknesses.

Teachers, as direct participants in STEAM education, their own STEAM education literacy and the design of STEAM courses by teachers directly affect the quality of STEAM education. First of all, teachers should possess the integrated quality of interdisciplinary education. Teachers not only need to possess professional subject knowledge, but also need to have the ability to learn across disciplines, being able to integrate knowledge from multiple disciplines or specialties. Only in this way can the next generation of students they cultivate apply interdisciplinary knowledge to solve complex problems, conduct interdisciplinary communication, and cope with the complex and ever-changing society. Secondly, teachers should possess the technical literacy of integrating resources and using tools. In STEAM teaching, teachers often need to provide resources for students by selecting tools (such as 3D printing, computers, etc.) in specific project-based teaching, and present abstract knowledge to students through intuitive means to enhance students' interest in learning. Finally, teachers should possess the core quality of an innovative spirit. STEAM education, as a form of education aimed at cultivating innovative talents, focuses on fostering students' ability to solve real-world problems and their creative and innovative capabilities. The rapidly changing practice of knowledge production and the constantly developing students have made the originally complex teaching even more complicated. The courage to innovate has become the new expectation and requirement of The Times for teachers.

5. Feasibility Analysis of Introducing the STEAM Education Concept in the Classroom Teaching of "Robots"

STEAM education is oriented towards identifying and solving problems, and conducts teaching practice activities that connect various disciplines. The mathematical physics method, on the other hand, starts from solving the practical problems of physics and engineering, and proposes and solves problems. The main task of the course is to enable students to learn how to describe practical physical or engineering problems with definite solutions in mathematics and master various methods for finding definite solutions, such as the method of separating variables, Fourier series method, and power series solution method, etc. It usually involves three main steps: comprehensively applying physical knowledge and mathematical tools to derive the definite solution problem; Solve definite solution problems by using mathematical means; Analysis of the physical meaning of equation solutions In other words, this course can be based on mathematics and interpret science and technology from the perspectives of engineering and art, which coincides with the STEAM education concept.

The problem-driven teaching model is the most important mode of STEAM education. This education emphasizes the knowledge connections among different disciplines and guides students to use interdisciplinary thinking to learn and solve specific practical problems, aiming to promote the all-round development of students. "Robotics" is both a mathematics course and a physics course. The course focuses on cultivating students' ability to express "physical problems" using "mathematical language", and emphasizes whether students can apply mathematical thinking to analyze problems in fields such as physics and engineering. Its short-term goal is to help students master the necessary mathematical knowledge and tools. To lay a necessary mathematical foundation for subsequent specialized courses, the long-term goal is to enrich students' mathematical thinking, train their mathematical thinking, and enable them to have the ability to skillfully apply mathematical tools to handle specific problems. It is evident that the nature and teaching objectives of the "Robotics" course share similarities with the educational philosophy of STEAM. It is feasible and forward-looking to implement the concept of STEAM education in the teaching practice of this course. It can bring classroom teaching back from merely imparting knowledge to the track of people-oriented and comprehensive education, and practice the concept of "student development-centered" [18].

6. Conclusion

The robot curriculum system constructed in this study takes interdisciplinary integration as the core and reintegrates the traditional single-discipline curriculum into a modular curriculum system. The basic modules include mathematical modeling, physical mechanics, etc., providing students with a solid theoretical foundation. The core professional modules cover robot programming, mechanical structure design, sensor technology, etc., to cultivate students' core professional skills. The extension modules offer courses such as artificial intelligence and Robotics, robot art design, and robot ethics to broaden students' horizons and stimulate their innovative thinking. This modular curriculum system enables students to systematically study robot-related knowledge while achieving the organic integration and expansion of knowledge, laying a solid foundation for subsequent practical innovation. The robot curriculum system constructed in this study takes interdisciplinary integration as the core and reintegrates the traditional single-discipline curriculum into a modular curriculum system. The basic modules include mathematical modeling, physical mechanics, etc., providing students with a solid theoretical foundation. The core professional modules cover robot programming, mechanical structure design, sensor technology, etc., to cultivate students' core professional skills. The extension modules offer courses such as artificial intelligence and Robotics, robot art design, and robot ethics to broaden students' horizons and stimulate their innovative thinking. This modular curriculum system enables students to systematically study robot-related knowledge while achieving the organic integration and expansion of knowledge, laying a solid foundation for subsequent practical innovation.

7. Conflict of Interest

The authors declare that there are no conflict of interests, we do not have any possible conflicts of interest.

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