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University Physics Teaching Based on STEAM Education Concepts

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STEAM education, which integrates science, technology, engineering, art, and mathematics across multiple disciplines, aims to cultivate students' interdisciplinary thinking ability, creativity, problem-solving ability, and practical skills. As a compulsory basic course for science and engineering students, the university physics course is characterized by cross-disciplinary integration. The main purpose of its teaching is to enable students to master the fundamental knowledge and theories of physics, cultivate their ability to analyze and solve problems, and enhance their scientific literacy, which is in line with the concept of STEAM education. Based on the concept of STEAM education, applying project-oriented teaching, a teaching method that is problem-focused, student-centered, and project-based, to the teaching of university physics, helps to improve the quality of teaching as well as the quality of talent cultivation.

Keywords: STEAM education, university physics, talent development, project-oriented teaching

Introduction

In recent years, the concept of STEAM education has gained widespread attention on an international scale. Since this concept was first put forward in the United States, several countries have incorporated it into the field of their education, making positive contributions to the cultivation of a large number of comprehensive talents. In China, although the adoption of STEAM education started relatively late, it had gained significant attention and has been widely promoted and popularized with rapid economic development and continuous education reforms. The core of the STEAM education concept lies in the comprehensive cultivation of students' comprehensive ability, which not only focuses on the learning of subject knowledge and technology but also pays more attention to the cultivation of the student's overall quality and innovation ability (Shi, Gao, & Ma, 2017). As a basic compulsory course for science and engineering students, the university physics course provides a solid cornerstone for their subsequent professional studies and plays a crucial role in developing students' scientific literacy and comprehensive ability. Therefore, the teaching of university physics should follow the development of the times and the changes in social needs, and strengthen the cultivation of students' scientific thinking and innovation ability. The integration of STEAM education concepts into university physics courses and the use of project-oriented teaching can not only improve the quality of teaching, but also better adapt to the social demand for high-quality talents, and cultivate more comprehensive talents with innovative spirit and practical ability for the society.

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The History of STEAM Education

STEAM education originated in the United States, and its development can be roughly divided into three main stages: the STS education stage, the STEM education stage, and the STEAM education stage. The STS (science, technology, and society) education stage began in the 1960s and 1970s, a period marked by high enthusiasm for the advancement of science and technology in American society. During this time, the relationship between science, technology, and society became a focal point of academic and social interest, leading to extensive exploration and study of their interconnections (Fan, Zhao, & Zhang, 2018). STS education emphasizes the interaction and impact of science and technology on society, encouraging students to consider the implications of scientific and technological developments on culture, politics, and the environment, to cultivate their critical thinking and social responsibility. As time progressed and global competition intensified, people gradually realized the importance of the fields of science, technology, engineering, and mathematics (STEM) and entered the stage of STEM education. At the beginning of the 21st century, STEM education began to receive widespread attention and was regarded as the key to fostering innovative talents and promoting economic development. STEM education emphasizes cross-disciplinary integration and hands-on learning and is committed to fostering scientific thinking, problem-solving skills, and teamwork among students. At this stage, STEM education has been widely supported and promoted by governments, schools, and enterprises, and has become one of the important directions of education reform. On this basis, people have gradually recognized the importance of art to creative thinking and innovation. In 2006, American educator Georgette Yakman first put forward the concept of STEAM (science, technology, engineering, art, and mathematics) education, integrating art elements into STEM education and forming the concept and framework of STEAM education (Zhao & Lu, 2016). STEAM education not only emphasizes science, technology, engineering, and mathematics learning, but also focuses on cultivating students' aesthetic sense, imagination, and creativity. Through the integration of art and STEM disciplines, STEAM education provides students with a richer and more integrated learning experience, stimulating their interest in learning and unlocking their creative potential.

In China, the development of STEAM education is relatively late, starting around the beginning of the 21st century. With the rapid development of the Chinese economy and the continuous reform of the education system, people gradually realized that traditional education could no longer meet society's demand for diversified and innovative talents. As a result, interdisciplinary and innovative education began to receive more and more attention. Around 2010, some schools and educational institutions in China began to experiment with integrating artistic elements into the teaching of science, technology, engineering, and math and launched a series of pilot projects on STEAM education. Over time, STEAM education has gradually spread across China, with more and more schools and educational institutions offering STEAM-related courses and activities to develop students' comprehensive abilities and innovative spirit. In recent years, the Chinese government has also increased its attention to STEAM education, incorporating it into one of the key areas of national education reform. Some local governments and education departments have also introduced relevant policies to support and promote the development of STEAM education. At the same time, many science and technology enterprises and cultural organizations have also actively invested resources to carry out various projects and activities related to STEAM education, contributing to the overall development of students and the cultivation of innovation ability.

In the development history of the United States, STEAM education came into being and gradually developed and matured, forming a perfect STEAM education system. Other countries have also begun to gradually pay

attention to and actively promote the development of STEAM education, aiming to improve the quality of national talent training and enhance national competitiveness.

The Connotation of STEAM Education

STEAM education, a comprehensive education that integrates science, technology, engineering, art, and mathematics, aims to develop students' interdisciplinary thinking, creativity, problem-solving, and practical skills (Zhao & Lu, 2016). Professor Georgette Yakman has conducted extensive research on STEAM education, organically linking various disciplines and constructing a framework for STEAM education, which is an important guide for educators to design teaching models and improve teaching and learning activities (Zhao & Lu, 2016). In the framework constructed by Professor Georgette Yakman, the top layer represents the ultimate goal, emphasizing that STEAM education is lifelong and interconnected with lifelong learning. The second layer is the integrated layer, which emphasizes that STEAM education supports the integration of multiple disciplines, encouraging students to identify and solve problems through an interdisciplinary approach, thereby developing their ability to independently apply multidisciplinary knowledge to problem-solving. The third layer is the art penetration layer, which underscores the inclusion of arts and other humanistic elements in STEM education, aiming to enhance students' humanistic qualities by integrating arts into various disciplines. The fourth layer is the disciplinary layer, i.e., the disciplines of science, technology, engineering, arts, and math. The lowest layer is the specific content layer, detailing the components of science, technology, engineering, arts, and mathematics. STEAM education is not merely a teaching method but also a reflection of educational philosophy and values. It aims to nurture talents with comprehensive literacy, innovative spirit, and a sense of social responsibility through an interdisciplinary approach, preparing them to cope with the complex and ever-changing social and economic environments and to contribute to the sustainable development and progress of society.

The Characteristics of STEAM Education

STEAM education, as an educational methodology and philosophy, has many features that not only reflect its difference from traditional educational models but also highlight its advantages in cultivating students' comprehensive and innovative abilities.

Interdisciplinary Integration

STEAM education integrates science, technology, engineering, art, and math, breaking down the boundaries between traditional disciplines and promoting interaction and integration of knowledge (Li, 2019). Specifically, through scientific inquiry, technology application, engineering practice, artistic expression, and mathematical computation, students can understand the nature of a problem in a multi-dimensional and in-depth way and transform it into a solution. This interdisciplinary learning approach can stimulate students' creative potential and develop their comprehensive thinking skills. In such an educational environment, students can not only have an in-depth understanding of traditional subjects but also be able to flexibly apply interdisciplinary knowledge to complex real-world problems. When implementing STEAM education, teachers usually encourage students to actively explore and experiment both inside and outside the classroom, and to integrate interdisciplinary knowledge through project-based learning, collaborative research, and hands-on practice. For example, students may be involved in a robotics programming project that requires not only computer programming skills but also

an understanding of engineering principles and perhaps the creation of digital artwork, as well as learning how to design and analyze with mathematical tools.

Practical Learning

STEAM education emphasizes learning by doing, with practical learning at its core, encouraging students to apply the theoretical knowledge they learn in the classroom to real-life and social problems. This type of learning is not only limited to the traditional classroom mode of instruction, but through a series of well-designed projects and experimental activities, allowing students to personally participate in them and experience the transformation process from concepts to finished products. In this process, students are not just passive recipients of information but become active learners, explorers, and creators. Through designing, producing, and completing various projects, students master knowledge from practice and develop problem-solving skills and an innovative spirit.

Creative Thinking

The cultivation of creative thinking plays a pivotal role in STEAM education, which is not only a part of the education system but also a unique teaching concept. Art, as a core element of this philosophy, opens up an unlimited window of creativity and imagination for students. In this realm, students are free to express their innermost feelings and thoughts, transforming their personal worldviews, values, and emotional experiences into concrete and vivid works through painting, music, theatre, and many other forms. Such a process is not only the enhancement of skills but also the exercise of aesthetic ability and expression, which helps students develop sharper observation, deeper understanding, and more excellent creativity.

Teamwork

STEAM education encourages students to work together in teams to solve problems and develop teamwork and communication skills. In actual project tasks, students are often required to assign tasks according to team objectives, and in the process coordinate and cooperate to complete the tasks together, thus cultivating team spirit and a sense of cooperation. Through this learning experience, students can not only improve their skills and knowledge, but also cultivate teamwork and cooperation awareness, which will be extremely important soft power for them in the future, both in the workplace and in social life.

Problem Orientation

STEAM education is problem-oriented, emphasizing stimulating students' interest in learning and active inquiry, and cultivating their problem-solving abilities. In STEAM education, students find ways to solve problems and come up with innovative solutions through inquiry, analysis, and experimentation. Problem-oriented teaching encourages students to think outside the traditional learning framework and to learn independently by constantly asking questions and searching for answers. This model pushes students to become active explorers, willing to try out new methods and tools. At the same time, it stimulates students' curiosity, thereby increasing their critical thinking. Such a learning approach provides a platform for students to explore the unknown, enabling them to grow and progress in solving real-world problems.

Personalized Learning

STEAM education is student-centered, fully respecting students' individuality and interests, and stimulating their learning motivation and potential. In STEAM education, teachers will design personalized learning plans

and activities according to the different characteristics and needs of students, and provide targeted teaching and guidance for each student.

Global Perspective

In the wave of globalization, STEAM education plays a crucial role. It is not only an educational model but also an important way to develop students' global perspectives. Through this type of education, students will be able to cross national boundaries and cultural barriers to understand and learn about scientific, technological, and innovative achievements from all over the world. They will have the opportunity to participate in international exchange activities, collaborate with peers from different countries to solve problems, and explore the frontiers of science and technology. Such experiences can greatly broaden students' international perspectives and enable them to face future challenges with greater confidence. At the same time, this process can also significantly enhance their cross-cultural communication skills, enabling students to navigate in a multicultural environment.

Overall, the characteristics of STEAM education embody a brand-new educational concept and teaching mode that breaks through the boundaries of traditional disciplines and emphasizes interdisciplinary integration, practical learning, creative thinking, teamwork, problem orientation, personalized learning, and global perspective. Through STEAM education, students can comprehensively develop their abilities, cultivate their scientific literacy and innovative spirit, and enhance their teamwork, communication, and problem-solving skills.

Construction of University Physics Course Teaching Model Based on STEAM Education Concept

The university physics course is a basic course required for science and engineering students, with the characteristic of cross-disciplinary integration which matches with the concept of STEAM education. The main purpose of its teaching is to enable students to master the basic knowledge and fundamental theories of physics, cultivate students' ability to analyze and solve problems, improve students' scientific literacy, and lay a solid foundation for subsequent professional learning and further study. However, in the traditional teaching of university physics courses, teachers pay too much attention to the teaching of students' theoretical knowledge of physics, focusing on theory but not practice, lacking the cultivation of students' practical and innovative abilities (Wang, Wang, & Han, 2022). Moreover, in the process of teaching, due to the lack of connection with other disciplines, the student's ability to comprehensively use the knowledge of various disciplines to think about problems and solve problems cannot be cultivated and improved. STEAM education emphasizes the integration of science, technology, engineering, art, and mathematics to achieve comprehensive interdisciplinary training. Its core objective is to enable students to master knowledge and skills across various fields through the integration and crossover of multiple disciplines, thereby promoting their all-round development. Therefore, it is necessary and feasible to introduce STEAM education in the teaching of university physics courses. Combined with the characteristics of university physics courses and the current teaching situation of university physics courses, based on the concept of STEAM education, we can effectively improve the quality of teaching and talent cultivation by constructing a project-oriented teaching mode.

Project-oriented teaching is a problem-centered, student-focused, project-based teaching method, which aims to cultivate students' comprehensive ability through the way of "learning by doing" (Tan & He, 2014). It emphasizes problem-driven learning through meaningful learning tasks that prompt students to think and explore.

Through project practice, students are guided to carry out independent learning, cooperative learning, and inquiry-based learning, to stimulate their spirit of exploration and sense of innovation, and improve their ability to solve practical problems. Project-oriented teaching requires students to discuss, investigate, and practice around problems, to develop their problem-solving ability, innovation, and teamwork, as well as their critical and logical thinking skills. Through project design and implementation, students need to apply what they have learned to solve real problems which can deepen their understanding and mastery of knowledge. In addition, interdisciplinary knowledge is often involved in the process of project-oriented teaching and learning, which helps students fully understand the application of what they have learned in different fields. In the teaching process, teachers generally play the roles of "guides" and "mentors", stimulating students' interest and participation in learning through various ways and encouraging them to explore and cooperate.

In the actual teaching process, teachers can introduce project-oriented teaching into university physics teaching by choosing appropriate projects, providing guidance and support, organizing teamwork, and assessing learning outcomes. Teachers can make students understand physical principles and theories in the process of problem-solving by selecting challenging and inspiring projects related to the course content. At the beginning of the project, teachers can provide guidance and support to help students clarify the problem, analyze it, and develop a solution. Teachers can also group students and organize teamwork so that students can communicate and cooperate in groups to solve problems together. Finally, teachers can assess students' learning outcomes in the form of project reports, presentations, or discussions, to promote students' in-depth understanding of knowledge and application ability.

Conclusion

STEAM education is a novel educational approach and educational philosophy, based on science, technology, engineering, and mathematics (STEM), integrating multiple disciplines, and infiltrating humanistic elements such as art. According to the characteristics and actual situation of university physics courses, applying the STEAM education concept to the teaching of university physics courses through the project-oriented teaching mode can fully mobilize students' learning interest, improve students' independent learning ability and problem-solving ability, and stimulate students' innovative consciousness and innovative thinking.

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