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The Integration Of Higher Engineering Education And STEAM Education In China: Current Situation, Challenges And Future

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ABSTRACT

This article explores the integration of STEAM (Science, Technology, Engineering, Art, and Mathematics) education in higher engineering education in China, focusing on analyzing its development history, current situation, and the necessity of such integration. The importance of engineering education, its origin and development, and the introduction of STEAM education. The limitations of traditional education are discussed by incorporating innovative and humanistic elements. Although China's higher engineering education has made significant progress, there are still problems in the integration of STEAM. This article also proposes strategies for curriculum innovation, project-based learning, teaching method improvement, and teacher development, and provides policy and practical suggestions for promoting STEAM integration in China's engineering education system. Future research directions include evaluating the effectiveness of interdisciplinary teaching methods and using advanced technology to enhance STEAM education.

Keywords: higher engineering education; STEAM education; college curriculum reform

INTRODUCTION

Marx once said: "Large-scale industry incorporates huge natural forces and natural science into the production process, which will inevitably greatly improve labor productivity" (Marx, K. 1867). Since the Industrial Revolution, the development of engineering science and the application of engineering technology have become an important part of promoting social production. During the Cold War, driven by the space race and military innovation between the United States and the Soviet Union, both countries invested significant resources in engineering education. This marked the beginning of modern engineering education becoming a critical component of national security and economic growth. The advent of the information age and globalization in the late 20th century further transformed engineering education. The rise of digital technology, the Internet and global communications networks requires a new generation of engineers versed in emerging technologies. Universities around the world are beginning to internationalize their curricula and research collaborations, fostering the development of a more connected global engineering education ecosystem. At the same time, the original STEM education began to be promoted in the American education sector in the 1990s, aiming to improve the level of talent cultivation in the fields of science and technology to meet the needs of global technological competition (Breiner et al., 2012). Over time, educators and researchers have realized that education in science and technology alone is not enough to fully cultivate students' ability to innovate and solve complex problems. Therefore, in the mid-2000s, art was introduced into STEM education, forming the STEAM education model. This change reflects recognition of the importance of creativity and humanistic literacy in the technological innovation process (Land, 2013). Since COVID-19, facing the rapid changes in the global political landscape, and in the context of globalization, the integration of STEAM education and higher engineering education has become an increasingly relevant topic in the context of China's education reform. STEAM education aims to develop comprehensive skills including critical thinking, creativity, and interdisciplinary knowledge that are critical for innovation and problem solving in the modern world (Yakman, 2008). In China, integrating STEAM into higher engineering education is seen as a strategic approach to improve the quality of engineering graduates and ensure that they meet the needs of the rapidly changing technological environment. This article explores the integration of STEAM education and higher engineering education in China, analyzing its potential benefits, challenges, and future directions.

The current development status of higher engineering education

China's higher engineering education has made significant progress over the past few decades, becoming one of the world's largest producers of engineering graduates (Marginson, 2011). China's higher engineering education has greatly improved both in quantity and quality. According to data from the Chinese Ministry of Education, as of 2020, there are more than 3,000 higher education institutions in China, including nearly 600 engineering colleges. The scale of enrollment in engineering majors is also constantly expanding. In 2020, the number of enrollment in engineering majors nationwide will reach 2 million. Higher engineering education in China has made significant progress in recent years. According to the "Times Higher Education China Subject Rankings 2024", China's performance in the field of engineering is particularly outstanding, with a total of 290 universities receiving an A+ rating in at least one engineering discipline; since the "New Engineering" policy was proposed in 2017, China's performance in engineering has increased Comprehensive reforms were carried out in education. These reforms include establishing a new curriculum system, promoting industry-university-research cooperation, and vigorously developing interdisciplinary education to adapt to the needs of new technologies and industrial development; China's engineering education covers a wide range of subject areas, including aerospace, agricultural engineering, biomedicine Engineering, chemical engineering, civil engineering, computer science and technology, electrical engineering, environmental science and engineering, etc. Each university performs well in these subject areas, especially in fields such as biomedical engineering, computer science and technology, and chemical engineering. With the country's continued investment and policy support for engineering education, China's engineering education will continue to grow and develop in the future. By continuously optimizing the allocation of educational resources and improving teaching quality, China is expected to cultivate more internationally competitive engineering and technical talents and make greater contributions to global technological innovation and industrial upgrading (Times Higher Education (THE), 2024). However, there are still challenges in the development of higher engineering education in China, especially in cultivating students' creativity and practical problem-solving abilities. Traditional engineering education in China has been criticized for its overemphasis on rote learning and theoretical knowledge, often neglecting hands-on learning and innovation (Chen, 2016). The gap between teaching content and actual engineering needs is an urgent problem that needs to be solved. The course content of many universities is relatively outdated and lacks close integration with the latest technology and industry needs. This disconnect leads to insufficient practical and innovative abilities of graduates, making it difficult to meet the needs of the rapidly developing industrial and technological fields. Although China's engineering education reform, especially the "new engineering" education reform, has made some progress, it still faces many difficulties in actual operation. For example, the reform of curriculum systems among colleges and universities requires time and a lot of investment, and the existing education system and traditional concepts are sometimes difficult to quickly adapt to new requirements. In addition, the promotion of interdisciplinary cooperation and the integration of industry, academia and research also faces certain resistance. Therefore, in the face of the current development status of higher engineering education in China, through continuous reform and optimization of the education system, strengthening the connections between universities, and weakening the distance between textbooks and practice, China is expected to further improve the quality of engineering education and cultivate more high-level students in the future. High-quality engineering and technical personnel.

The connotation and development status of STEAM education

STEAM education, that is, science, technology, engineering, art, and mathematics education, has experienced multiple stages of development. The original STEM education began to be promoted in the American education sector in the 1990s, aiming to improve the level of talent training in the fields of science and technology to meet the needs of global technological competition (Breiner et al., 2012). Over time, educators and researchers have realized that education in science and technology alone is not enough to fully cultivate students' ability to innovate and solve complex problems. Therefore, in the mid-2000s, art was introduced into STEM education, forming the STEAM education model. This change reflects recognition of the importance of creativity and humanistic literacy in the technological innovation process (Land, 2013).

At present, STEAM education has received widespread attention and application around the world. The education policies of many countries and regions include elements of STEAM education, aiming to cultivate students with multi-disciplinary knowledge and innovative abilities (Kim & Park, 2012). In China, the government and educational institutions actively promote the development of STEAM education and improve the quality of education through curriculum reform and teacher training (Wang & Wang, 2016). Since 2016, the concept of STEM education has gradually appeared in China's national and local policy documents, becoming an important part of promoting education reform. At the same time, many schools and non-profit organizations are also carrying out various STEAM projects to encourage students to participate in interdisciplinary learning and practical activities. Many schools have established STEM professional classrooms or maker spaces to promote project-based learning. And in November 2023, a resolution was passed to establish the International STEM Education Research Institute in Shanghai, China. In general, the development of STEM education in China is in a period of rapid growth. With further policy support and continuous innovation of education models, greater progress is expected to be made in the future. However, there are also some problems in the practice process, such as formalization of project implementation, hardware construction of resources, and fragmentation of curriculum development.

The necessity of integrating higher engineering education and STEAM education

For today's world situation and the economic benefits that engineering can bring, the integration of higher engineering education and STEAM education (Science, Technology, Engineering, Art and Mathematics) is of great necessity and practical significance. In today's context of globalization and the rapid development of science and technology, the single-discipline education model can no longer meet the needs of society and industry for comprehensive talents. We not only require the talents we train to have excellent knowledge, but also hope that these talents have their own value judgment and aesthetic ability. Therefore, STEAM education emphasizes interdisciplinary integration and aims to cultivate students' creativity and problem-solving abilities by organically combining science, technology, engineering, art and mathematics. In traditional higher engineering education, students often focus too much on the learning of technical and theoretical knowledge and neglect the

cultivation of humanistic qualities and creative thinking. This will lead to students' learning methods that are not profound enough, and even the knowledge cannot become effective knowledge, but can only be a memory in the brain. By introducing the concept of STEAM education and promoting the integration of the two, we hope to break down the barriers between disciplines, prompt students to think about problems from multiple perspectives, and cultivate their innovative consciousness and practical abilities.

Secondly, modern engineering problems are often complex and diverse, requiring the comprehensive application of multidisciplinary knowledge and skills. The integration of higher engineering education and STEAM education can help students better cope with these challenges. By integrating art into engineering education, students can be inspired to innovate and improve their design capabilities. For example, industrial design, architectural design and other fields need to combine engineering technology with artistic aesthetics to create products and buildings that are both practical and beautiful; aesthetic education represented by art can not only improve students' aesthetics, but also improve students' aesthetics through aesthetic education. Providing them with life and love education can greatly improve students' self-efficacy and promote healthy physical and mental development.

In addition, STEAM education focuses on practice and project-based learning, which is highly consistent with the practice orientation of higher engineering education. In engineering education, experiments, internships and project practices are important ways to cultivate students' practical ability and ability to solve practical problems. By introducing the project-based learning method of STEAM education, students can comprehensively apply the knowledge they have learned in actual projects and improve teamwork and communication skills. Moreover, in today's globalization context, the integration of higher engineering education and STEAM education can also help cultivate students' sense of social responsibility and global perspective. Modern society faces many global problems, such as climate change, energy crisis, environmental pollution, etc. The solutions to these problems require the combination of engineering technology and social sciences. Through STEAM education, students can not only learn scientific and engineering knowledge, but also understand the application of this knowledge in society and its impact on society, thereby cultivating their sense of social responsibility and global perspective.

Current situation of application of STEAM education in higher engineering education in China

As China's top engineering school, Tsinghua University is at the forefront of the implementation of STEAM education. The school cultivates students' innovative abilities and comprehensive qualities through interdisciplinary courses and project practices. For example, Tsinghua University's "Maker Space" project provides students with a practical platform integrating science, technology, engineering, art and mathematics. Students can engage in various creative design and engineering practices here to enhance their practical capabilities and innovative thinking. Similarly, Shanghai Jiao Tong University, a world-class university, also offers an "Engineering and Art" course to combine engineering knowledge with artistic creation. This course not only teaches students traditional engineering principles, but also guides them in problem solving through an artistic lens. Students enhance their understanding and application capabilities of the integration of engineering and art by participating in various interdisciplinary projects, such as smart furniture design, interactive installations, etc. The interdisciplinary innovation experimental class established by Zhejiang University aims to cultivate engineering talents with comprehensive qualities and innovative abilities. This experimental class breaks the boundaries of traditional subjects and integrates content from science, technology, engineering, art and mathematics. During the learning process, students participated in a number of practical projects, such as drone design, intelligent robot development, etc. Through these projects, they cultivated teamwork spirit and interdisciplinary problem-solving abilities.

These colleges and universities blend science, technology, engineering, arts and mathematics with the goal of empowering students to think and solve problems from multiple perspectives. Driven by actual projects, students learn in practice and can better master knowledge and apply it in practice. Through innovation platforms such as maker spaces and interdisciplinary experimental classes, a good atmosphere for innovation has been created, stimulating students' imagination and creativity, and improving students' thinking skills and critical thinking. However, at present, China still has insufficient professional teachers in STEAM education, resulting in uneven teaching quality. The STEAM curriculum in some schools is not perfect enough and lacks systematicity and scientificity, resulting in unsatisfactory teaching results. Due to resource differences between regions and schools, some schools face the problem of insufficient resources when implementing STEAM education. Moreover, traditional educational concepts are deeply rooted, and it takes a lot of time and effort to change educational concepts and accept and promote STEAM education. How to coordinate and unify the development of scientific and systematic STEAM courses in colleges and universities and establish an effective evaluation system is also a long-term problem.

PATHS AND STRATEGIES FOR THE INTEGRATION OF HIGHER ENGINEERING EDUCATION AND STEAM EDUCATION

Curriculum Reform and Innovation

Curriculum reform and innovation in higher engineering education are the key to realizing the integration of STEAM education (Science, Technology, Engineering, Art and Mathematics). However, due to the current lack of STEAM course offerings in colleges and universities and the uneven levels of STEAM course offerings among colleges and universities, as well as the lack of unified course content, curriculum reform and innovation are particularly important. The setting of STEAM courses should focus on the integration of subject knowledge, break down traditional subject barriers, and design integrated interdisciplinary courses so that students can use knowledge from multiple subjects when solving practical problems. For example, while studying mathematics and physics, engineering students should also receive training in art design and creative expression to develop comprehensive literacy and innovative abilities (Brown & Adler, 2008). And curriculum innovation is also an important way to

achieve the integration of STEAM education and higher engineering education. By creating relevant courses, these courses organically combine content from multiple disciplines such as science, technology, engineering, art, and mathematics, and even cultivate students' comprehensive qualities and ability to solve practical problems.

Project-based Learning

Project-Based Learning (PBL) is a student-centered teaching method that cultivates students' problem-solving skills and teamwork spirit by allowing them to participate in actual projects. In higher engineering education, the introduction of STEAM-related project-based learning can enable students to apply theoretical knowledge to practical problems, thereby improving learning effects. Students can participate in actual engineering projects, such as bridge design, robot production, etc., and consider not only the practicality of the design, but also the aesthetics of the design. Students can apply what they learn in practice. Moreover, universities can also cooperate with enterprises or scientific research institutions to provide students with more practical opportunities and resources to help students better apply theoretical knowledge to practical problems. The school can cooperate with enterprises to carry out internship projects, allowing students to carry out actual work in enterprises, understand and master the latest technologies and processes, thereby improving their employment competitiveness.

Teaching Methods and Assessment

In order to achieve the integration of STEAM education, higher engineering education needs to improve teaching methods and evaluation mechanisms. Traditional teaching methods often focus on lectures and ignore students' active participation and the cultivation of practical abilities. By introducing teaching methods such as inquiry-based learning and cooperative learning, students' learning interest and creativity can be stimulated. In addition, the evaluation mechanism should also be diversified. In addition to traditional written examinations, it should also include project results display, teamwork evaluation, flipped classroom or MOOC, etc., to give more initiative in the classroom to students to fully reflect students' learning effects. with process.

Teacher Training and Development

Teacher training and development in higher engineering education is the basis for realizing the integration of STEAM education. Teachers need to have interdisciplinary knowledge background and teaching abilities to effectively implement STEAM education. Therefore, schools should provide systematic teacher training to help teachers understand the latest educational concepts and teaching methods, and improve their professional quality and teaching level. In addition, teachers should also actively participate in academic exchanges and scientific research activities, and constantly update and expand their knowledge and skills. Teachers' professional development is an important guarantee for realizing the integration of STEAM education. Schools should provide teachers with various forms of professional development opportunities, such as teaching seminars, workshops, online courses, etc., to help teachers continuously improve their teaching abilities and professional qualities. At the same time, schools should also encourage teachers to conduct interdisciplinary teaching research and cooperation to jointly explore and innovate the teaching model of STEAM education.

SUGGESTIONS ON THE INTEGRATION OF HIGHER ENGINEERING EDUCATION AND STEAM EDUCATION

Policy Suggestion

The government and education departments should formulate policies to encourage the establishment of interdisciplinary cooperation mechanisms between universities and scientific research institutions and promote the in-depth integration of engineering education and science, technology, engineering, art, and mathematics (STEAM) education. This can be achieved by establishing dedicated funds to support interdisciplinary research projects and teaching reform pilots. Formulate and implement curriculum reform policies and integrate STEAM education concepts into the engineering education curriculum system. The syllabus can be revised and interdisciplinary courses and project practices can be added to ensure that students can comprehensively apply knowledge and skills from different disciplines during the learning process. In addition, the government should introduce policies to support teachers in conducting STEAM education-related training and improve teachers' interdisciplinary teaching capabilities. Special training funds can be set up to organize training courses at home and abroad to improve the professional quality and teaching level of teachers.

Practical Suggestions

Colleges and universities should promote interdisciplinary project practice, encourage students to participate in projects involving multiple disciplines, and cultivate their comprehensive problem-solving abilities. For example, colleges and universities should design and implement comprehensive projects covering engineering design, programming, artistic creation, and mathematical analysis to promote students to apply the knowledge they have learned in practical operations. And set up a STEAM innovation laboratory to provide necessary hardware facilities and resources to support students in carrying out independent innovation and research activities. The laboratory can serve as a base for students to conduct interdisciplinary research and practice, cultivating their innovative thinking and practical abilities. In order to avoid the serious disconnect between the knowledge students learn and society, cooperative relationships should be established with enterprises and industry organizations, industry experts should be invited to participate in teaching, and real engineering problems and projects should be provided for students to practice. Through internships, lectures, workshops and other forms, students can understand the latest trends in the industry and enhance their practical experience and employment competitiveness.

Future Research Directions

Future research can focus on exploring and evaluating the effects of different interdisciplinary teaching methods and identifying the most suitable teaching model for the integration of engineering education and STEAM education. Research can include case analysis, experimental research, etc., to evaluate students' improvement in knowledge mastery, skill development and innovation ability. Research how to use advanced technologies (such as virtual reality, artificial intelligence, data analysis, etc.) to improve the effectiveness of STEAM education, and explore the specific application of these technologies in interdisciplinary teaching and their impact on student learning outcomes. Evaluate existing education policies and implementation effects, analyze the successful experiences and shortcomings of policies in promoting the integration of engineering education and STEAM education, and provide scientific basis for further policy formulation.

CONCLUSION

This article explores the integration of STEAM education and higher engineering education in China and its necessity and challenges. By analyzing the development status of higher engineering education and STEAM education, the importance of the integration of the two in cultivating comprehensive innovative talents is clarified. China has made significant progress in the field of higher engineering education, but there are still deficiencies in the cultivation of practical capabilities and creativity. By introducing STEAM education, subject barriers can be broken, interdisciplinary thinking can be promoted, and students' comprehensive quality and innovation ability can be improved. Currently, some leading universities in China have achieved positive results in curriculum reform and project-based learning, demonstrating the potential of STEAM education in engineering education. However, the implementation process also faces problems such as insufficient teachers and imperfect curriculum. In order to further promote the integration of STEAM education in higher engineering education, multiple strategies including curriculum innovation, teaching method improvement, and teacher training need to be adopted. The policy suggestions and practical paths proposed in this article provide a reference for future education reform. Through continued research and practice, China is expected to occupy a more important position in global engineering education and cultivate more internationally competitive engineering and technical talents. Future research should focus on evaluating the effectiveness of different interdisciplinary teaching methods and exploring the application of advanced technology in STEAM education to further improve the quality and effectiveness of education.

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