The Influence of STEAM Education on the Improvment of Students' Creative Thinking*

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Abstract—**Interdisciplinary education is the cornerstone of cutting-edge science and the source of hi-tech. STEAM education is an effective means of interdisciplinary education, and innovation is a necessary complement to interdisciplinary education. STEAM education stems from STEM education and is better than STEM education, emphasizing on interdisciplinary methods and cultivating students' innovative abilities. The interdisciplinary education has a good effect on improving students' innovative ability. This paper first introduces the basic concepts of STEAM education, and then analyzes the impact of STEAM education on students' innovation ability. Finally, it discusses the implementation of STEAM education in teaching from several aspects: cultivating students' innovative ability from an interdisciplinary perspective, carrying out practical projects to improve students' innovative ability, and cultivating students' innovative ability to solve practical problems.**

Keywords—*STEAM education; innovation; interdisciplinary education*

I. Introduction

The rapid changes of modern society, the current era of global network information and knowledge economy, and the diversified development of society, make people need to learn more diverse and more flexible knowledge to adapt to this fast-developing society. Having the ability to innovate becomes a prerequisite for coping with the future diversified environment. Students with high level of innovation ability can more effectively solve the difficulties encountered in their study, life and future work, and adapt to the changes in the era of global network information technology. Therefore, how to effectively cultivate students' innovative ability has become a major teaching reform project in various schools.

The essence of innovation is creativity. Creativity refers to the use of the learned knowledge to produce a unique, novel and valuable product thinking [1].In the future social development, students should have the ability and quality to innovate. The innovation ability is constantly developing in students' learning and growing processes, and the congenital and acquired factors will affect the development of students' innovative ability. Innovative ability is achievable. As places for students to learn knowledge, schools need to cultivate and protect students' innovative ability through education and teaching practice [2].

II. The Basic Concepts of STEAM Education

STEAM is derived from STEM education. STEM education refers to the related education that integrates technology, science, engineering, and mathematics [3]. Technology refers to the effective tools or methods to solve problems; engineering refers to the knowledge of using scientific principles to create artificial objects; mathematics refers to the science that studies the relationships between numbers; they complement each other, support each other, and are often crossed and integrated in the processes of solving problems. STEM education focuses on science and engineering education. Later, people realized that the complete STEM education also needs the addition of the education of arts, so the STEM education evolved into the STEAM education and became the current educational trend [4].

The STEM education concept was first proposed by the American science education organization in 1986. This educational concept was supported and recognized by the government and relevant educational organizations, and relatively complete education systems were developed by professionals, which are also applied to the current STEAM education. STEAM Education is the innovative fusion of diversified disciplines and incorporates a variety of subject knowledge. This educational concept breaks the boundaries between disciplines in traditional education, allowing students to learn to integrate engineering, mathematics, science and other subject knowledge, take part in practice activities involving different disciplines and solve the problems encountered in study and life [5].

A. Emphasizing Interdisciplinary Learning

STEAM education emphasizes the integration of diverse disciplines, emphasizes the breaking of the boundaries between disciplines in teaching, emphasizes the interdisciplinary learning, has broken the boundaries between disciplines in traditional education, and integrates the subjects of engineering, mathematics, arts, science, etc. STEAM education allows students to link together specialized and fragmented knowledge, creates a relatively unified discipline, and allows students to view problems and solve problems in a complete mindset. STEAM education avoids the separation of knowledge of different disciplines. Interdisciplinary learning helps to develop students' creative ability [6] and learning ability.

B. Emphasizing Practical Problems

The cultivation of innovation ability should not stay at the abstraction and theory level, but should be integrated into the solution of practical problems, pay attention to the solution of practical problems, and attach importance to the real processes. The original intention of education is to let students learn the methods and skills to solve problems, and learning is the process of learning to solve problems. However, traditional education only pays attention to the teaching of textbook theories, ignores the core skills of learning, and does not pay attention to the cultivation of students' innovative ability, making students' ability to solve problems generally poor. And there are differences between the content of education and the real society, making it difficult for students to cope with the difficulties encountered in society[7].STEAM education breaks the traditional education mode, integrates various disciplines, improves students' ability to solve practical problems, and provides a new education and teaching model. In the STEAM education model, the problems encountered by students in the learning process are often the difficulties they will encounter in real life or in their future work, which are real, complex, diverse and similar. For unknown and vague practical problems, students can't find useful solutions from the theoretical knowledge in textbooks, which encourages them to research, discover, and make solutions or strategies to problems on the basis of the learned knowledge and combining with multiple subject knowledge [8]. Students constantly discover problems and solve problems with innovative thinking in the process of solving practical problems, which effectively improves students' innovative thinking ability.

III. The Impact of STEAM Education on Students' Creative Ability

STEAM education integrates multiple disciplines. Students do not study a single subject, but study mathematics, engineering, arts and other disciplines systematically. STEAM education breaks the traditional education model and uses the new thinking mode, new ideas, new knowledge framework, and diversified learning mode to bring students diverse learning experience. By solving practical problems, students can cultivate and improve their innovative design capabilities [9].It is researched and proved by international and domestic scholars that STEAM education promotes students' innovative ability from many aspects and at multiple levels, which is mainly reflected in the diversity, effectiveness and creativity of methods to solve practical problems [10].

Through the research of some mathematicians and scientists, it can be found that their successes are directly related to their erudition. It is not that they are only good at a certain subject, they are actually good at integrating multidisciplinary knowledge to form a whole knowledge system with multiple disciplines crossing and supporting each other [11]. STEAM education integrates arts with mathematics, engineering, science, technology and other disciplines. It not only develops and improves students' aesthetic and artistic acumen, but also improves students' operational ability, model making ability, spatial imagination, etc., making students have the innovative ability that they cannot have when studying in the traditional education mode [12].Through the STEAM education, students not only have the basic engineering science knowledge to solve practical problems, but also have a more diversified and innovative problem-solving ability. STEAM Education focuses on developing students' innovative abilities, helps students develop comprehensive and systematic innovative abilities and characters, and improves their comprehensive ability.

The core of innovation ability is creativity. The ability to create can be acquired and promoted through continuous learning and practice. Especially for students who are in their youth, the cultivation for creativity is the most critical. STEAM education can cultivate their diverse learning interests and abilities, and make them master the STEAM education knowledge system; and carry out learning projects based on practical problems, which can improve their innovative ability to solve practical problems. Students can verify whether their innovative ideas are effective through practical exercises which can help students to find problems and recognize their own shortcomings in the process of solving problems. STEAM Education advocates cross-integration learning of multiple disciplines, cultivates students to use divergent thinking to solve practical problems, fosters their innovative ability and helps them succeed in future social work [13].

STEAM Education develops students' innovative abilities in problem-based, project-based approaches that reproduce real-life scenarios. Project-based learning and problem-based learning are beneficial to students in developing their own learning goals and adapting their learning methods [14].Compared with the traditional education model, the project-based and problem-based learning methods help to improve students' interest in learning and enable students to participate in the STEAM education. Students solve related problems by integrating the multidisciplinary knowledge they have learned. This helps them identify key issues, motivates their innovative thinking to solve problems, transforms them from passive learning to active learning, improves their ability to solve problems, and improves their team organization ability, making them have the ability to quickly adapt to the fast-changing information society.

IV. THE SPECIFIC IMPLEMENTATION OF STEAM EDUCATION IN TEACHING

The implementation of STEAM education in practical teaching should reflect the above basic concepts and characteristics: from the interdisciplinary perspective; carrying out problem-based, project-based practical activities; requiring students to learn to solve practical problems; cultivating students' innovative ability; and guiding students to use divergent thinking and innovative ideas to solve practical problems.

A. Cultivating Students' Innovative Ability From the Interdisciplinary Perspective

STEAM Education emphasizes the cross-integration of mathematics, engineering, science, arts and other disciplines. Therefore, schools can develop STEAM education through the use of modern information network technology, setting up interdisciplinary courses, and the preparation of teaching materials to promote the development of students' innovative ability. First of all, the use of modern information network technology enables teachers to pass on the teaching content to students through a diversified teaching mode, so that students can more deeply understand the teaching content and learn better in the STEAM education mode. Students can also collect, organize, and analyze more knowledge through online means to find ways to effectively solve problems [15].Secondly, the school should provide a variety of courses to meet the needs of different students, and strictly control the professional qualities of the courses, and then give students the right to choose the projects freely, guide students to use project-based, problem-based methods to learn effectively. Carrying out interdisciplinary education through the above-mentioned ways, integrating the multiple disciplines, and making students use a variety of innovative thinking to find suitable materials and tools to solve the corresponding problems will certainly help the cultivation of innovative talents.

B. Carrying out Practical Projects to Cultivate Students' Innovative Ability

STEAM Education focuses on getting students to practice. Creativity is similar to the muscles of the human body. Keeping exercise can make the muscles more flexible. Learning is also the same. Allowing students to continuously verify the knowledge they have learned in practical projects and insisting on carrying out project practice for students can continuously develop students' technological creativity and ability to solve problems. The practice of projects should not only be the basic verification of the knowledge acquired, but also motivate students to solve problems in different creative ways. To achieve the above teaching goals, schools and teachers need to focus on cultivating students' interest in learning when implementing the STEAM education. Individuals who want to have high level of creativity often need to have the persistent learning attitude. Unless the student himself has a strong motivation to learn, it is necessary to encourage students to start from their favorite subjects, and then gradually learn the knowledge of other subjects. And students can develop their creativity through the communication with other students or by studying on the Internet.

C. From the Perspective of Real Situations, Cultivating Students' Ability to Solve Problems

STEAM Education emphasizes that students should solve problems in real situations and attaches importance to project-based, problem-based learning with projects as the core. The authenticity of the projects lies in the comprehensiveness and authenticity of the problems. The problems students will encounter in their future life and work are often complex and diverse, and they are more difficult than problems encountered by students in the classes. Therefore, it is required that the problems involve the knowledge of multiple disciplines, so that students need to use interdisciplinary knowledge to solve problems, which helps students to use the knowledge they have learned to solve practical problems. Take the "Pulley labor saving device" project as an example. This is the knowledge that junior high school students have learned in class. STEAM education requires students to design and produce labor-saving devices after understanding the scientific theories and knowledge, and finally participate in group competitions. The teacher first explains the scientific principles, and then explains the safe use of common tools to students, such as 3D printers, CNC milling machines, laser cutting machines and other digital devices. After that, students freely team up to design, produce and debug the devices. In this project, students are introduced to the principles and uses of the labor-saving device, which reflects the "science" subject knowledge in STEAM education; learning to use digital equipment reflects the "technology" subject knowledge; the parts used in the students' designs of the devices reflect the knowledge of "engineering" discipline; and the assembly of parts reflects the knowledge of "arts" discipline. Finally, the adjustment of the pulley labor-saving device (such as selecting suitable fixed pulleys and moving pulleys, pulley direction, rope length, etc.) embodies the knowledge of "mathematics" discipline. In this real-life-based project, students have experienced a multidisciplinary, problem-based STEAM education that helps improve their ability to innovate.

It should be noted that the school needs a good education platform for project-based and problem-based learning. The school should establish an open STEAM education platform and combine online network learning with offline lab hands-on practice. Students can freely and openly conduct STEAM learning and access resources through the network; there are various digital devices (such as CNC milling machines, 3D printers, laser cutting machines, etc.), open source hardware, etc. in the laboratories. Students can conduct project-based learning in the laboratories under the guidance of the instructors. It is the goal of STEAM education to make students integrate the learned subject knowledge, solve practical problems under real situations, stimulate students' interest in learning, and improve their creative ability and teamwork ability, which also provides a guarantee for the cultivation of innovative talents.

V. CONCLUSION

STEAM education has gradually become the development trend of China's recent education, but its current status of immature development in China will face certain difficulties in the implementation of education in the future and slow down the pace of development. The implementation of STEAM education is not aimed at the specific and detailed reform of a certain subject, but it should be used as an entry point to promote the comprehensive development of education in China, promote curriculum reform, make up for the shortage of curriculum teachers, outdated teaching materials and single teaching mode and explore the talent training model to realize the all-round development of students under the concept of quality education, and enables students to possess 21st century skills. It is believed that under the joint promotion of the government and education departments and educational institutions, both STEAM education and "research-based learning" courses will cultivate more complex innovative talents.

REFERENCES

[1] Bie Dunrong. Vision of creative talent training [J]. China Higher Education Research, 2016, 12: pp.11-18. 别敦荣.创造性人才培养的视野[J].中国高教研究,2016,12:11-18.

[2] Fu Bajun. From creative talents, creative education to entrepreneurial universities [J]. Efficient education management, 2017, 04 (11): pp.71-75. 付八军.从创造性人才、创造性教育到创业型大学[J].高效教育管理,2017,04(11):71-75

[3] Zhao Xinglong, Xu Lin. Five major controversies on STEAM educationand the responses [J]. Electrification education. 2016, (10): pp.62-65. 赵兴龙,许林.STEAM 教育的五大争议及回应[J].做过电化教育.2016,(10):62-65

[4] Gao Yunfeng, Shi Baoguo. The Integration of Maker Education and STEAM Education in the Interdisciplinary Innovation Vision[J]. Journal of East China Normal University, 2017, 04(35): pp.47-53. 高云峰,师保国.跨学科创新视觉下创客教育与 STEAM 教育的融合[J].华东师范大学学报,2017,04(35):47-53.

[5] Li Xiaotao, Gao Haiyan, et al. The change from STEAM education to maker education in the context of "Internet +" - from project-based learning to the cultivation of innovative ability[J]. Journal of Distance Education, 2016, 01(34): pp.28 -36. 李小涛,高海燕等."互联网+"背景下的 STEAM 教育到创客教育之变迁-从基于项目的学习到创新能力的培养[J].远程教育杂志,2016,01(34):28-36.

[6] Yang Xiaozhe, Ren Youqun. STEM Education and Maker Education in the Digital Age[J]. Open Education Research, 2015, 05(21): pp.35-40. 杨晓哲,任友群.数字化时的 STEM 教育与创客教育[J].开放教育研究,2015,05(21):35-40.

[7] Zhong Zhixian. Theories and Educational Technologies ofMultiple Intelligence [J]. E-education Research, 2001, 3: pp.7-11. 钟志贤.多元智能理论与教育技术[J].电化教育研究,2001,3:7-11.

[8] Yuan Lei, Zhao Yuting. Research on the deep integration of STEAM concepts and the "research study" course in primary schools [J]. Modern distance education, 2018, 01: pp.50-56. 袁磊,赵玉婷.STEAM 理念与小学"研究性学习"课程的深度融合研究[J].现代远距离教育,2018,01:50-56.

[9] Shi Baoguo, Luo Jin, et al. The Promotion Effect of Multicultural Experience on Creativity and Its Implications of Education[J].Journal of Inner Mongolia Normal University, 2016,29(2):pp.123-127. 师保国,罗劲等.多元文化经验对创造性的促进效应及其教育意蕴[J].内蒙古师范大学学报,2016,29(2):123-127.

[10] Saracho O N. Contemporary perspectives on research in creativity in early childhood education[M]. Maryland: IAP, 2012.

[11] Shi Baoguo, Gao Yunfeng ,et al. The influence of STEAM education on students' innovative literacy and its implementation strategy [J]. China Educational Technology, 2017, 04: pp.75-79. 师保国,高云峰等.STEAM 教育对学生创新素养的影响及其实施策略[J].中国电化教育,2017,04:75-79.

[12] Root-Bernstein R. Arts and crafts as adjuncts to STEM education to foster creativity in gifted and talented students[J]. Asia Pacific Education Review, 2015,16(2):pp.1-10.

[13] Lubinski D, Benbow C P, Webb R M, et al. Tracking exceptional human capital over two decades [J]. Psychological Science, 2006, 17(3): pp.194-199.

[14] Hu Tianzhu. STEAM and its enlightenment on the construction of new engineering subjects[J]. Higher Engineering Education Research, 2018, 01: pp.118-124. 胡天助.STEAM 及其对新工科建设的启示[J].高等工程教育研究,2018,01:118-124.

[15] Yang Xianmin, Zhao Xinshuo. Construction and development of digital education resources in the era of "Internet +" [J]. China Educational Technology, 2017, 10: pp.51-59. 杨现民,赵鑫硕."互联网+"时代数字教育资源的建设与发展[J].中国电化教育,2017,10:51-59.