

Development, Characteristic and Enlightenment of STEAM Education in the United States

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Abstract: *STEAM is a popular educational concept around the world. It originated in the United States and has a development history of decades. STEAM has an assignable influence on the United States. It is one of the important weapons for the United States to remain strong and has begun to affect the rest of the world. STEAM education in the United States mainly went through four stages: STS, STSE, STEM and STEAM. Through traversing these four stages, we summarize the characteristics of STEAM education in the United States and summarize the enlightenment of its successful development, which is of great benefit to the global implementation of STEAM education.*

Keywords: *STEAM Education; United States; stem education*

1. Introduction

STEAM education is an interdisciplinary comprehensive education. Each letter in its name represents a discipline, namely science, technology, engineering, art, and mathematics. The predecessor of STEAM education is STEM education, which is a brand-new educational concept born by joining the discipline of art on the basis of STEM. STEAM education originated in the United States and has also been systematically developed in the United States. Now this kind of educational philosophy has been popularized worldwide. The American STEAM education system is relatively mature and the system logic is strong, and it has formed a certain role for other countries to learn from. The development of American STEAM education has mainly experienced four stages: STS, STSE, STEM and STEAM. In these four stages, STS is the embryonic form of the development of STEAM education; STSE is the result of further exploration of STS; STEM is the most prevalent and at the same time the most recognized stage; STEAM is a relatively new concept, still a lot of research is needed to promote its development.

From the development process of STEAM education in the United States, it can be seen that each development stage of STEAM education has different characteristics, and the development of each stage is to solve the social problems arising in different periods. The reason why the United States has always been a technological power has an inseparable relationship with STEAM education. To a certain extent, the success of STEAM education development is directly related to whether a country can rank among the big science and technology countries. Therefore, sorting out the development of STEAM education in the United States, summarizing the characteristics of STEAM education, and summing up the successful experience of the United States is of great significance to other countries.

2. The development history of American STEAM education

2.1. Enlightenment: STS stage

STS is the collective name of science, technology, and society, and some scholars have understood its meaning as "Science and Technology Studies" (Science and Technology Studies). STS was born in the United States in the 1960s and has been developed along with solving social problems in the following decades. STS was born in the aftermath of World War II, when the United States experienced a long period of "pseudo-prosperity", and the rapid development of science and technology brought unprecedented impact to the United States. But when time passed by the 1960s, the negative impact brought about by scientific and technological progress extinguished the United States' enthusiasm for the continued development of science and technology, and the first thing to bear was environmental issues. The environment that has been heavily polluted due to the long-term development of industry

and technology has posed a huge threat to the national environment and people's health in the United States, and has led to demonstrations by the American masses. In addition, the Vietnam War and the rise of European countries aggravated the turmoil in American society at that time to a certain extent. Faced with this situation, the US government successively established the "Environmental Protection Agency" and the "Occupational Safety and Health Administration" in the 1970s, and passed the "Air and Water Cleaning Act" [1]. At this time, the United States finally realized that it is not advisable to completely ignore the society and the people and blindly develop science and technology. More and more scientific researchers have begun to re-examine the relationship between science and technology and society. They believe that the social factor should be added on the basis of science and technology. As a result, under the influence of many social issues, STS came into being.

In addition to solving social problems, the emergence of STS has its academic significance. The early STS was often accompanied by a strong "anti-technology" atmosphere, such as "Technology Road" published by Jacques Ellul [2] and "Machine Mythology" by Lewis Mumford [3]. The most influential in this regard was the "Two Cultures" speech delivered by STS expert Charles Percy Snow at Cambridge University in 1959, which intensified the opposition between science and technology and society. Although the publication of these journals and speeches has brought radical features to STS, the appearance of these results has enriched the academic connotation of STS to some extent. At the same time, the American academic community was vigorously opposing the tendency of highly diversified subjects and advocating the development of interdisciplinary education. The emergence of STS, a comprehensive field, just conforms to the trend of the times, and has obtained a large amount of resource tilt, so that it can formally enter the school education system. In general, it was the joint promotion of society and education that contributed to the emergence and development of STS.

2.2. Exploration: STSE stage

STS has eased social conflicts in the United States to a certain extent, but its development process has not been smooth sailing, and there are still some problems that need to be adjusted and optimized. In 1996, the United States put forward the concept of STSE education for the first time when formulating national curriculum standards [4]. STSE, as the name suggests, is the result of exploring the most prominent environmental problems by adding the factor of environment on the basis of STS. Compared with STS education, STSE education further emphasizes the coordinated development of science, technology, society, and the environment, and pays more attention to the sustainable development concept and the cultivation of citizen scientific literacy. These concepts are mainly reflected in science and chemistry that are closely related to environmental issues. .

As a transitional education between STS and STEM, the research on STSE is not very thorough and comprehensive, and there are different opinions on STSE. A currently highly recognized argument is that STSE education is biased towards a guiding ideology of science education. On the basis of STS training talents, environmental education interventions are further added to enable the trained talents to have better scientific literacy and Knowledge of the natural environment.

2.3. Prosperity: STEM stage

STEM is an interdisciplinary education that is popular all over the world. Its name is taken from the first letters of the four words science, technology, engineering and mathematics. Compared with the characteristics of STS and STSE that passively solve social problems, STEM is considered to be an education mode that actively discovers problems and finds solutions. The "Undergraduate Science, Mathematics, and Engineering Education" report issued by the National Science Board (NSB) in 1986 is regarded as the beginning of STEM education. In 2005, the National Academy of Sciences (NAS), National Academy of Engineering (NAE), Academy of Medical Sciences (IOM), and National Research Council (NRC) jointly issued the report "Harnessing the Storm: America Mobilizes for a Brighter Future", the main content of the report It is to increase the scale of STEM education. The release of this report has greatly promoted the implementation of STEM education in the United States. In 2007, the National Science Council again proposed to extend STEM education from undergraduate to elementary and secondary education, laying the foundation for the prevalence of STEM education in K-12 education. In 2011, U.S. President Barack Obama put forward the view that "the future economic growth and international competitiveness of the United States are directly related to national innovation capabilities" and initiated an educational innovation campaign. In the educational innovation movement, STEM education has been given the highest priority and the greatest strength, and STEM education has thus formally moved onto the stage of the international community.

STEM education focuses on the integration of multiple disciplines and fields, and emphasizes the importance of independent learning and collaborative learning. The purpose is to improve students' innovative ability and problem-solving ability. STEM education usually adopts the project teaching method to teach. By allowing students to complete tasks in a real situation, they can subtly understand and master the knowledge that STEM education wants to impart. At present, with economic growth and technological progress, societies in various countries are paying more and more attention to the cultivation of innovative abilities and innovative talents, and STEM education has therefore become an important way to cultivate innovative talents. However, the development of STEM education in most countries in the world is still in its infancy. Many countries have only mechanically transplanted the US STEM education model, and have not formulated policies to localize STEM education in line with their own national conditions. To sum up, judging from the successful experience of STEM education in the United States, STEM is not only a mode of education, but also a means of national development. The research on STEM education in various countries in the world is still deepening.

2.4. Sublimation: STEAM stage

STEAM adds "A" (art) on the basis of STEM. Traditional STEM education is mainly oriented to science and engineering subjects, causing many young students in the K-12 education stage to lack interest in these relatively boring learning content. In 2006, the American scholar Georgette Yakman first proposed adding art as an important component to the original STEM education structure [5]. On this basis, Yakman further proposed a new concept of STEAM education and integrated the basic framework of STEAM education. On the other hand, the relationship between art and STEM technology is the closest. Without the support of art, technology is difficult to develop. Without technology, learning mathematics will be very difficult, making it difficult to master science, and even harder to create engineering. Therefore, the STEAM education philosophy is not born out of thin air, but is based on evidence.

STEAM is a relatively new educational concept proposed on the basis of STEM. In order to promote the development of STEAM education, the US government has adopted a series of measures to support it. For example, in 2011, the Rhode Island School of Design (RISD) published the "Connecting STEM and STEAM" theme report [6]; in 2014, the American Art Education Association (NAEA) formulated four STEAM standards; in 2015, Obama proposed to art education Incorporated into the K-12 education system [7]. With the support of these reports and policies, STEAM education has developed rapidly in the United States and even around the world in recent years, and it seems to have had the momentum of STEM education that year. However, as a discipline education that has only received attention in recent years, the status of art education is far from being compared with science, which has brought great results to the United States. Some people even regard art and science as two opposites. Education. The consequence of this kind of thinking is that art cannot have the same status as sciences, which is more abrupt in the entire STEAM system. Nowadays, although STEAM education is very popular in the education field in the world, the main promotion of the US government is still STEM education. The issue of how art can be integrated into STEM is still worth thinking about.

3. Characteristics of American STEAM education

3.1. Comprehensiveness

STEAM education is an interdisciplinary educational concept, and its most distinctive feature is its comprehensiveness. Since STEAM education integrates the five disciplines of science, technology, engineering, art, and mathematics, the knowledge systems of the five disciplines are different. Therefore, the knowledge transfer of STEAM education also divides the knowledge by discipline. The emergence of STEAM education breaks the tendency of subject division, and helps students understand complex science and engineering knowledge.

3.2. Situationality

STEAM education is usually based on the real educational situation to complete its teaching process. Project-based learning is the most commonly used educational method in STEAM. Under this kind of education model, teachers focus on individual projects and use real situations as the educational environment, focusing on cultivating students' ability to solve practical problems. Students can choose their own learning content, plan their learning time, and arrange their learning progress reasonably.

Exploiting the contextual characteristics of STEAM education can enable students to have the ability to transfer knowledge, so that they can apply the knowledge they have mastered more flexibly in their future learning careers.

3.3. Practicality

Because it includes disciplines such as technology and engineering, STEAM education also has strong requirements for practical ability. For example, in art education, STEAM education must first cultivate the students' sense of beauty, and then externalize the knowledge taught through the design of works, and finally help students form artistic quality. In addition, collaborative learning is an important way to conduct STEAM. Students often work in groups to complete the implicit learning tasks in the project, and the final evaluation process is also carried out in groups. STEAM is different from traditional education concepts, it emphasizes collaboration and practice, and improves the quality of teaching through role changes.

4. The enlightenment of American STEAM education

Looking at the vigorous development of STEAM education in the United States, we can conclude many experiences for other countries to learn from. First, the national government and educational institutions should provide sufficient resources for STEAM education, such as strengthening the quality of basic education, attaching importance to the composition of the teacher team, and increasing the design of cross-curricular courses. Second, we must actively apply information technology to the STEAM education system. In this era of educational informatization, information technology can greatly assist the conduct of STEAM education, and at the same time, it can also improve the quality of STEAM education to a certain extent. Third, we must attach importance to the important role of collaborative learning under the STEAM education philosophy and advocate the construction of a learning community.

5. Conclusion

From the full text, we can understand that the development of STEAM education in the United States has experienced four main stages, from the enlightened STS and STSE to the gradually mature STEM, to today's STEAM. The progress of each stage is accompanied by the solution of specific problems, so it has different characteristics of the times. This article believes that STEAM education in the United States has the three most significant characteristics of comprehensiveness, situationality and practicality. On the basis of grasping these three main characteristics and combining the various stages of the development of American STEAM education, finding the inspiration for the successful development of American STEAM education can provide a reference for the development of related education in other countries to a large extent.

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