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Literature Analysis and Research Prospects of Computational Thinking Education in Primary and Secondary Schools in China from the Perspective of STEAM

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ABSTRACT
STEAM education is widely valued as a model of interdisciplinary learning mode, and computational thinking is selected as one of the top ten technologies that will have a profound impact on education in the next three to five years. This paper follows the research hotspots, categorizes the literature on developing computational thinking under the STEAM concept retrieved from the Chinese database of China Knowledge Network, analyzes and summarizes the value and problems of the existing literature, and finally provides an outlook on the research on developing computational thinking from the perspective of STEAM education.

Keywords: *STEAM education, computational thinking, information technology curriculum*

1. INTRODUCTION

In today's world where integrated teaching of disciplines is advocated, STEAM education responds to the needs of the times by teaching the five dimensions of science, technology, engineering, art, and mathematics as a whole activity, and in addition to enhancing students' literacy in these five dimensions It also tries to enhance students' innovation and comprehensive problem-solving skills. The concept of computational thinking was formally introduced by Professor Yi-Zhen Zhou in 2006, who believed that computational thinking is a series of thinking activities that cover the breadth of computer science, such as problem solving, system design, and understanding of human behavior using the basic concepts of computer science[1]. The main purpose of developing students' computational thinking skills is to hope that they can use computational thinking to solve real-world problems creatively; therefore, from the perspective of students' development, STEAM education is similar to computational thinking education. This study focuses on the trends in the development of STEAM education and computational thinking education in China, conducts a systematic analysis of existing research, compares the existing achievements in the development of computational thinking education in China from the perspective of STEAM education, discusses the value of existing research, and analyses the problems that arise in the development of research, aiming to provide a reference for the development of STEAM + computational thinking education and promote the development of computational thinking education from the perspective of STEAM The aim is to provide a reference for the development of STEAM + computational thinking education and promote the development of computational thinking education from a STEAM perspective towards formalization and standardization.

In this study, based on the CNKI Chinese literature database, 42 articles were searched with the topics of "STEAM" and "computational thinking", and the volume of articles is shown in Figure 1.

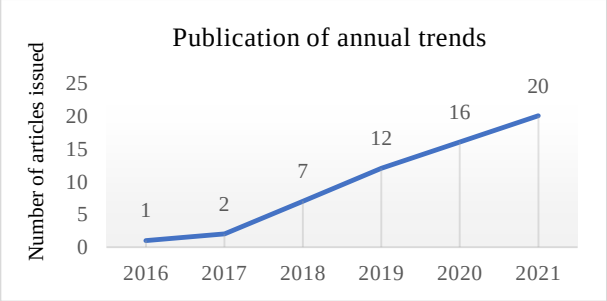

Figure 1 Analysis of "STEAM + Computational Thinking" research

From Figure 1, it is very intuitive to see that the research on developing students' computational thinking skills with the STEAM education concept is on the rise, from only 1 in 2016 to 16 in 2020, with more and more researchers trying to explore the connection between the both.

2. COMPUTATIONAL THINKING EDUCATION IN STEAM PERSPECTIVE

STEAM education has been given high expectations since its introduction, and its integration of the five dimensions is considered the key to interdisciplinary problem solving; while computational thinking, as a way of thinking, seeks to enable people to solve problems from the perspective of a computer scientist; therefore, from a goal-oriented perspective, both the STEAM education concept and computational thinking are aimed at problem solving. In the actual research process, because of the differences in researchers' perspectives, different understandings have emerged so far, which can be summarized as follows.

2.1 Information Technology Curriculum Perspective

Front-line teachers in primary and secondary schools would understand STEAM education and computational thinking from the IT curriculum perspective, and they view the development of computational thinking in terms of the core literacy of the IT discipline. For example, from the STEAM education perspective, Yangzhi Lai in Guangzhou City believes that this subject-integrated teaching concept integrated into the elementary school IT classroom can promote students' core literacy development, in which a task-driven, project-based learning approach can better develop students' computational thinking[2]. Lu Chongmin, on the other hand, based on the perspective of IT teaching, proposed the view that thinking is the heart of STEAM education and computational thinking is the technical pillar of STEAM activities[3]. Yi-Bing Huang uses the STEAM education concept as a theoretical basis for a classroom paradigm shift in the middle school IT classroom, using the question-and-answer method to develop students' computational thinking and guide them to find solutions to problems during the teaching process[4].

Some teachers also hold another view that IT courses based on the STEAM education concept should facilitate the transition from computational thinking to design thinking. In his article, Zhao Yu pointed out that the information technology curriculum under the STEAM education concept should be different from the traditional curriculum. Computational thinking is to analyze and solve problems from the perspective of computer science, and as an interdisciplinary teaching concept of STEAM, it is obviously inappropriate to follow only technical thinking, so from the perspective of curriculum design, the transition from computational thinking to design thinking should be achieved, and design thinking is the problem-solving thinking in line with the STEAM education concept[5].

2.2Computational thinking skills enhancement perspective

Research on computational thinking skills enhancement based on the STEAM education concept is to look at STEAM as a general context on which specific teaching methods such as task-driven and project-based are used, still focusing on programming content and incorporating more diverse topics to achieve the effect of developing students' computational thinking skills. This type of research can be subdivided into two parts: one is to study only how to enhance students' computational thinking skills, and the other is to explore the development of computational thinking skills in terms of core literacies.

In terms of improving students' computational thinking skills, Yang Yu designed the "Virtual Robot" STEAM project, which uses the online 3D robot simulation platform of Radish Circle to try to develop computational thinking skills of secondary school students[6]. In her research, Wang Yan believes that computational thinking, as an interdisciplinary problem-solving mindset, has many similarities with the goal of interdisciplinary and real-life problem solving in STEAM education to enhance students' innovation ability, and it is also an effective way to develop students' computational thinking through STEAM education projects. that investigates the development of students' computational thinking skills[7]. There are also some dissertations that provide more detailed studies on how to enhance students' computational thinking under the STEAM education concept. For example, in his study, Gong Taotao used the STEAM education concept as a guide, and used the smart car as a platform to "talk" about science, "learn" about technology, "do" about engineering, "seek" about art, and "seek" about computational thinking. In his study, he used a smart cart as a platform to improve students' computational thinking skills through five STEAM education components:

"talking" science, "learning" technology, "doing" engineering, "seeking" art, and "investigating" mathematics, combined with project-based learning[8]. Sun Shuyang's study used the Scratch platform to design a STEAM-based fun math project, and after a period of teaching practice, the results showed that the designed teaching content was helpful in improving students' computational thinking skills[9].

From the aspect of core literacy, the core literacy of student development mainly refers to the character and key competencies that students should possess and are necessary to be able to adapt to the needs of lifelong development and social development[10]. After doing a series of systematic analysis, Jia-Liang Shao constructed STEAM core literacies with Chinese characteristics, in which scientific thinking method is one of the literacies, and scientific thinking, computational thinking, engineering thinking, mathematical thinking, and artistic thinking are divided from STEAM subject areas[11]. Ma Zhongji conducted a study on the interactive design of STEAM-based programming curriculum for children, in which he pointed out that programming thinking should include the five dimensions of scientific thinking, computational thinking, verbal thinking, systems thinking, and design thinking[12]. Other researchers have studied the development of students' core literacies under the concept of creativity and STEAM integration. Some studies have pointed out that the engineering domain in STEAM education has been the weak link, and integrating creators into STEAM education can provide successful examples in the engineering domain, which can achieve the effect of optimizing STEAM education[13]. Wang Mengke's study was based on such a perspective and developed a 12-lesson integrated course based on STEAM and creator education concepts, and the measurement results after teaching practice showed that students' computational thinking skills level was improved[14].

In summary, the above-mentioned studies on computational thinking education from STEAM perspective not only broaden the ideas for the development of computational thinking education, but also provide experiences that can be used for better STEAM education. From these existing studies, it is easy to find that both STEAM education and the cultivation of computational thinking are gradually being emphasized by all sectors.

3.ANALYSIS OF EXISTING STUDIES

3.1The value of the study is reflected

3.1.1 The attention of computational thinking education integrated with STEAM concept is enhanced

Both STEAM education and computational thinking education are currently hot educational topics. The integration of STEAM education concept and computational thinking education is not only a new demand for the development of these two kinds of education, but also a full indication that front-line teachers or experts and scholars have put forward more new thinking about both kinds of education. In the context of advocating integrated application of knowledge and interdisciplinary learning, the STEAM education concept lays the cornerstone for the development of interdisciplinary learning, while computational thinking provides the guarantee for integrated application of knowledge and creative problem solving from the technical perspective. Therefore, it is a win-win situation for the development of STEAM education and computational thinking education that computational thinking education from STEAM perspective can get wide attention.

3.1.2 Gradually enriching theoretical connotation and laying the foundation for future education development

Thanks to the development of STEAM education and computational thinking education, the connotation of computational thinking education based on STEAM perspective has been gradually enriched, and more and more researchers are looking at STEAM education from a multi-faceted perspective and thinking about the relationship between computational thinking, core literacy and comprehensive ability under this perspective, building many novel and diverse connotations of STEAM education concepts, which provide the theoretical foundation for the more diversified development of STEAM education in the future.

3.1.3 Research content becomes more diverse and promotes the cultivation of comprehensive talents

The research content of computational thinking education from STEAM perspective is getting richer and richer, from simple programming knowledge to cell phone software development using App Inventor, from software level knowledge learning to soft and hard robotics education content, as well as some research combined with other knowledge such as science popularization and environmental protection, all of which are making an effort for the big change of education. As STEAM education becomes more important and programming and artificial intelligence courses become more popular, the "STEAM+" education concept will accelerate the development of comprehensive talents.

3.2 Problems highlighted by the study

3.2.1 Incomplete research

Some of the studies on cultivating computational thinking or core literacy based on the STEAM education concept are incomplete, and the reasons can be categorized into two situations. One is that STEAM education requires teachers to design reasonable teaching projects and to have certain requirements on their own knowledge reserves, while front-line teachers have limited abilities and are limited in conducting detailed research. Another phenomenon of incomplete research is that the STEAM education concept or computational thinking education is only used unilaterally as a nod to the article, but in fact there is no specific research content, and it is not really a research based on the STEAM education concept to cultivate computational ability.

3.2.2 Thinking evaluation method is not perfect

An important problem facing the cultivation of computational thinking based on the concept of STEAM education is that the way of evaluating computational thinking is not perfect. At present, the evaluation of computational thinking is still in the development stage, and the common evaluation methods at this stage include interviews, work analysis, computational thinking scales, and Bebras computational thinking challenge test questions, but these evaluation methods focus on different directions, and the corresponding computational thinking theory also differs, which causes the research conclusions to be ambiguous. The development of computational thinking based on STEAM concepts or core literacies is limited by the way in which the enhancement of thinking skills is evaluated. Second, changes in computational thinking skills need to be studied over a long period of time in order to have better results, and the changes in computational thinking skills measured in a short research period are not obvious.

3.2.3 There is a "technical knowledge only" yoke

The current recognized and effective way to develop computational thinking is through programming-related educational content, so some of the studies show the phenomenon of "technical knowledge only," which is different from the phenomenon of incomplete research. The "technical knowledge only" phenomenon is based on the STEAM education concept, and the programming content is used to develop computational thinking, but in the whole research process, the multidimensional and multidisciplinary teaching content is not designed according to the STEAM education concept, which is against the original intention of the research.

4. PROSPECTS FOR FUTURE RESEARCH

Based on the existing research, with the background of China's educational policies and educational reality, and drawing on the excellent foreign experiences, this study proposes an outlook on the research on the cultivation of computational thinking of primary and secondary school students under the perspective of STEAM in China.

4.1 Research on strengthening teacher training

As the builders and implementers of the curriculum, teachers should reserve more and more knowledge and learn more teaching skills. In China, there are no full-time STEAM teachers in primary and secondary education, and part-time teachers are lacking in both subject knowledge and related technology applications, so it is especially important to study how to train front-line teachers to be competent in STEAM education, what training system to use, and what training content to use. Computational thinking, as an important thinking in applying information technology, corresponds to the technology dimension in STEAM education, and how teachers can develop students' computational thinking through technology content and apply it in the whole STEAM curriculum is another key content, which requires systematic training for frontline teachers who are also working in STEAM education. In their study, some Korean scholars introduced a STEAM training program for in-service teachers in Korea, which is divided into three stages: introductory, basic, and advanced, and the training uses a hybrid online and offline approach to enhance teachers' understanding and application of STEAM education[15].

China can refer to this model and make use of the currently well-established online education platform in China to link university teachers with frontline teachers to form a professional team to conduct training. This hybrid approach can be a direction for STEAM teacher training research.

4.2. Research on expanding STEAM special education content

In recent years, as the state and various localities have attached importance to information technology education, various documents or notices have been issued one after another, such as Chongqing Municipality's "Notice of Chongqing Education Information Technology and Equipment Center on the Issuance of Work Points in 2018" issued in March 2018, which clearly requires the development of STEAM education research in primary and secondary schools, such as Chongqing issued the notice of Chongqing education information technology and equipment center on printing and distributing the key points of work in 2018 in March 2018, which clearly requires to carry out steam education

research in primary and secondary schools, actively promote primary and secondary schools to carry out steam education pilot, and do a good job in the research on the key project of comprehensive education reform pilot "pilot of scientific and technological innovation reform in primary and secondary schools", Promote the reform of scientific and technological innovation education in primary and secondary schools[16]. From this document, we can see that STEAM as an educational concept has become a driving force for educational development, and is forming a very characteristic "STEAM+" education.

Overseas studies have used STEAM+ to awaken university students' interest in sustainable development and to promote appropriate attention to social issues[17]. Some studies have also embedded STEAM concepts into architecture disciplines to develop students' interdisciplinary problem-solving and collaboration skills, and use technology to explore different production methods to prepare students for the future[18]. Second, studies have been conducted in China to explore how to develop open source hardware curriculum based on computational thinking at the primary and secondary school levels[19]. Building STEAM+ education can be done from that perspective by integrating relevant open-source hardware knowledge, combining special project themes, and using STEAM concepts as a guide to develop students' computational thinking with the help of open-source hardware.

Therefore, this paper argues that to expand the content of STEAM education, we can develop curriculum based on technology, regional culture, social development, and biological science to cultivate students' computational thinking skills, and innovate cultivation methods to leave the phenomenon of "technical knowledge only" and let computational thinking go beyond the field of computer science education with the STEAM education concept. The concept of STEAM education can be used to realize the real interdisciplinary application of computer science education.

4.3 Computational thinking evaluation system research

Several existing evaluation methods of computational thinking have not yet formed a complete evaluation system from a holistic point of view, and the proliferation of the phenomenon of "technical knowledge only" has led to the evaluation of computational thinking to be more inclined to the examination of programming aspects, while ignoring the thinking characteristics of computational thinking and the changes in thinking ability. To make up for the shortcomings of scientific and effective computational thinking evaluation tools and to strengthen the research of computational thinking evaluation system will help the development of computational thinking education and expand the scope of application of computational thinking in STEAM and other educational concepts.

5. CONCLUSION

STEAM education, as a typical interdisciplinary learning approach, provides a proving ground for computational thinking to go beyond the computer discipline and broaden the scope of application. While conforming to the development of education, computational thinking education based on STEAM concept will become the focus of future research attention.

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