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Localization Practice of STEM Education
A Review Based on the CNKI Dissertation Database

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ABSTRACT
STEM education originated from Western European and American countries, which had attracted widespread attention in educational circles in recent years. China is also actively learning this concept and integrating it into all stages of Chinese education. This review article aims to sort out the relevant research results of localization practice of STEM education and classify and summarize them from three aspects: researches on STEM education in the West, Practice in each education stage, Evaluation and comparative study of STEM education. This review mainly focuses on the master's degree theses of young Chinese scholars since 2016. By combing the research results of young scholars, it is hoped that other scholars can better understand the current situation and problems of the localization practice of STEM education and further give enlightenment to the future STEM education in China.

Keywords: *STEM education, China, Localization Practice.*

1. INTRODUCTION

STEM education mainly originated from the west, but it has developed rapidly in China in recent years and has been widely discussed in academic and educational fields.

This paper aims to sort out the relevant achievements on the localization practice of STEM education. Specifically, taking the dissertation database of CNKI as an example, through sorting out the relevant research on STEM education topics of young scholars in recent years, this paper aims to understand the main concerns of Chinese scholars on localization practice of STEM education, as well as their topic selection background, reasons, methods, and research value.

This paper is based on 173 dissertations, most of which are master's dissertations, mainly from 2016 to 2020. According to the research topic, those dissertations can be roughly divided into three categories: Firstly, researches on the development of STEM education in European and American countries. Secondly, researches on the Localization Practice of STEM education in China. Finally, researches on the evaluation of STEM education. In terms of quantity, the second part accounts for the vast majority. About 68.9% of the articles are carrying out localization practice research.

2. RESEARCH AND PRACTICE OF STEM EDUCATION IN CHINA

2.1. Researches on STEM education in the West

Before discussing the practice of STEM education localization, some articles first focus on the main experience, specific measures, and relevant policies of Western Europe and the United States in STEM education.

STEM education is not the only responsibility of the school. The government, school, family, and society all play different roles in it. Tan talked about the main implementation path of STEM education in the UK, which is mainly made by governments, schools, and social organizations, and each of them had different roles [1]. Ma emphasized the great importance of social participation in American and analyzed the interior and exterior reasons why the social power could participate in STEM education [2]. Guo introduced the background and policies that the federal government could promote the development of STEM education in the United States [3]. In addition, the establishment of STEM education centers also played an important part in American STEM education. This strategy and specific policy were promoted and used in Utah, Idaho, and Texas, and so on [4].

The specific implementation of STEM education in different stages had also been concerned. Yin analyzed five characteristics of the curriculum of American primary and secondary schools and gave five inspirations for Chinese primary schools' STEM education [5]. Wang discussed the STEM factors that appeared in the biology textbooks in junior high school and used some specific cases to analyze the STEM components [6]. Feng talked about the development and successful experiences of STEM education in American senior high schools and analyzed the specific implementations [7]. Li analyzed the goal of the establishment, the main target, the practical methods, and the distinctive project of the STEM education center by using the examples of six public universities' STEM education centers [8]. Some scholars paid attention to STEM education in Australia. Liu introduced the characteristics of the education policy in Australia to reduce the disparity between the men and women in the STEM field and mentioned the reduction of Australia's academic performance in some STEM subjects [9]. Wei reviewed the standards, accreditation process, and current situation of the pre-service science teachers in Australia [10].

In addition, STEM education also exposed some problems. Tian talked about the current situation and problems of American STEM education in the K-12 stage and presented the measurements taken in America. Then the author analyzed the successful experience and characteristics of cultivating STEM teachers and provided some enlightenment for Chinese STEM education in primary and secondary stages [11]. Mao summarized the development of STEM education in the United States and presented some manifestations of gender disparity in STEM. Furthermore, the paper analyzed the reasons why gender imbalance exists in STEM and pointed out the advantages [12].

2.2. Practice in each education stage

The researches on the practice of STEM education in China were mainly divided into learning stages and disciplines.

High school. Zhang talked about those ways to incorporate STEM philosophy into physics teaching in high schools. The research included three aspects: construction of high school physics teaching process based on the STEM education concept, design of high school teaching case based on the STEM education philosophy, and high school physics teaching practice based on the STEM education concept. After a series of research processes, the paper finally concluded that using engineering design projects or problems to integrate teaching content was a major path for high school physics teaching. Also, high school physics teaching based on the STEM concepts had a highly positive education value [13]. In Yin's study, the goal of STEM education was to put the curriculum knowledge into a real situation, which stimulated students' interests in learning. The STEM teaching mode adopted the PBL teaching method, making the students the teaching center and the question as to the teaching guide. It also used the 5E teaching method, which emphasized "facing all students," "inquiry learning," and "the spirit of cooperation". There were several problems on maths teaching currently: To solve more time for students to do maths exercises, teachers ignore to teach the origin of the concepts or formulas; to cope with the exam-oriented education, teachers and students lack time to research the basic concepts, so they might lose their mathematics spirits and innovative ability [14]. Zeng also paid attention to the teaching situation creation and believed that the high school physics STEM education should have the overall design characteristics, engineering integration, practice orientation, emphasis on cooperation, and diverse presentation. The teaching situation creation should follow the principles that cultivate the core physics quality. It could be divided into five steps: selecting teaching content, determining teaching objectives, selecting context materials, creating STEM scenarios, and evaluating the situation. The author also pointed out that the physics teaching situation had advantages, including higher students participation, wider source material, and practical orientation [15].

In addition to specific discipline research, Dong studied the professional development strategy of High School Biology teachers in China and summarized six characteristics of STEM curriculum, including situational nature, consistency, integration, direct observation, cooperative nature, and scientific nature. To realize the teachers' professional development, the paper believed that teachers should make full use of the situation, keep track of the progress, perfect the teaching structure, and creating a harmonious and cooperative relationship. For the schools, they should provide more learning opportunities for teachers, design a unique development path for each teacher and enhance the recruitment of teachers [16].

Junior middle school. In the investigation on the interdisciplinary literacy of middle school physics teachers based on STEM education, Gan summarized several characteristics of physics teachers' interdisciplinary literacy, including that: a) gender did not influence the level of interdisciplinary literacy of physics teachers; b) physics teachers had a high level of knowledge, but they could not integrate and use interdisciplinary knowledge; c) physics teachers had strong systematic thinking and scientific demonstration ability, but their ability of interdisciplinary experimental exploration was to be improved; d) physics teachers' ability of team cooperation was strong; e) the interdisciplinary consciousness of physics teachers was strong, but their interdisciplinary teaching consciousness needed to be improved. The author also proposed some specific suggestions for teachers, including that: physics

teachers should face the interdisciplinary teaching problems directly, establish the curriculum concept of interdisciplinary teaching and be conscious of improving their interdisciplinary literacy. At the same time, schools needed to carry out effective training and provide rewards for teachers [17].

It was different from the research on teacher groups. Liu paid attention to the characteristics of the students in junior middle school. The study found that students in the middle school had relatively good creativity but showed different performances on language and graphing tasks. Girls and boys had little different creativity inclination. Still, girls had a better creative thinking ability, and the students who had the STEM education before tended to have a higher creative thinking ability than the students who had not learned yet [18].

Primary school. Feng used a primary school as an example to illustrate the localization management of STEM education. His study found that the primary school advocated students to actively participate and encouraged them to use their hands and brains to explore the answers to the questions. The school in this case study paid attention to the development orientation of education. For instance, the school tried to avoid focusing only on advertising to others and one subject or program. This school also emphasized the characteristic construction of teaching bases such as building photoelectric and robot laboratories inside school and agriculture bases outside school. In addition, the school attached importance to the STEM educational exchange activities. They engaged in the provincial, city, and district level innovative competitions and won lots of prizes. The school demanded that the teachers learn lessons from other excellent STEM classes and teach and lead students better. The students often cooperated with each other. They used their own way to collect their data and designed questionnaires. They also needed to examine their feasibility [19].

The research of instructional design was a very important research topic. The research background of Su's article was that the Science Curriculum Standard for Compulsory Education in Primary Schools added the "technology and engineering" in the curriculum standard in February 2017. This paper designed a framework of primary science teaching. It was mainly divided into four parts: creating real problem situations, scientific inquiry, engineering design, exhibition, and evaluation. After an experiment of H primary school, the final results showed that using this instructional design could let students acquire interrelated knowledge and accumulate hands-on experience of practical operation, which increased their interests in STEM-related fields and their ability to solve complex problems. Based on the STEM educational idea, some teaching suggestions were proposed: designing the teaching goal based on the learning situation; combing the characteristics of the unit, creating real situations; adopting the student-oriented class mode; adopting a variety of learning evaluation methods [20].

In recent years, STEM education had become very popular in China. However, few people paid attention to the girls' performance in the STEM field. Strategies for teaching primary school girls in STEM did a research based on a 3D print curriculum in an elementary school in Shanghai Xuhui District. According to the survey, girls generally did worse in the STEM field than boys, which might be physical reasons, low self-evaluation, gender stereotype, the irrelevance of girls' life, and lack of models. The teaching method was formulated in the paper: to understand gender differences correctly, to encourage students to guess and trial on error, to set up a female model, to select content related to daily life, decomposition, and grouping. These approaches would do have a certain effect on girls, but the habitual thoughts and misconceptions could not be changed easily. To improve this situation, the teachers should put effort and the parents need to change their minds, as well as the power of government and social groups [21].

Preschool education. The development of children's playing instrument activities was very important in children's education. Yang redeveloped and evaluated children's playing teaching aids based on STEM education. In the first part, the research showed that the basic elements of the STEM-based children's teaching aids activities were the ways of integrated learning, the ways of defining the real situation of the tasks, and the way of group cooperative learning. Activities should be organized in the way of design lessons, operation lessons, game lessons. The second part found that children's creative behavior ability, operational behavior ability, and team cooperative behavior ability had significant differences. Categorizing according to the creative behaviors, there was an obvious difference among the specific observational behaviors. Categorizing according to gender, there were not significant abilities among the behavioral abilities. The third part pointed out that the children could participate in the process enthusiastically, but the depth and breadth of the role of the teachers in prompting were not enough. The quality and openness of the class atmosphere should be further promoted [22].

Secondary vocational education. The research of STEM education impacting vocational students' psychological health gathered 30 students in Taishan Polytechnic to introduce 3D printing technology class. The research found that STEM education positively affected emotion management, interpersonal communication, learning and goals, and adaptability to the vocational middle school students' mental health. STEM education prompted vocational middle school students. Finally, the author concluded three pieces of advice in the application of STEM education in vocational schools. The process of teaching focused on the students' emotional experience in STEM education.

Teaching evaluation should be objective and diversified in STEM education. Education content should meet the needs of students in STEM education [23].

2.3. Evaluation and comparative study of STEM Education

The basic elements of the STEM evaluation included the concept of the STEM education evaluation, standard, and content. It also incorporated the information collection tools and methods. Through the comparative analysis of the evaluation framework of collaborative problem-solving ability distributed by OECD, the author found that it was more appropriate to adopt the method of cross dimension in the compilation of the evaluation of the framework of collaborative problem-solving ability, and it was necessary to add the dimension of the interdisciplinary thinking. To develop the evaluation sySTEM, it was better to use computer technology and have problem situations [24].

In terms of evaluation research, Wei considered the performance process was equally important as the result of the performance. Based on the perspectives of learners, teachers, and researchers, the research showed that: a) the multi-view STEM problem-solving evaluation sySTEM was feasible and effective. b) the students' overall STEM problem-solving ability was high; this ability did not significantly differ among different genders. c) direct STEM problem-solving impact existed among each stage, and the performance process affected the result of the performance. d) the influencing factors included environmental support, recognition, emotional attitude, and high-order thinking, which directly impacted the STEM problem-solving performance [25].

In the comparative research, Wang selected one set of science textbooks for primary schools in China (Sue version) and the United States(SACL). From the analysis of the STEM education overview of the two editions of books, it could be concluded that former poetry, core issues, and themes in the expansion were mainly distributed in the life science, geographical science, and material science of the S type, which showed that both of the two editions consider the S as the core. Th SACL version had three times as many knowledge points as the Sue version. Also, both of the editions had infiltrated STEM education in the textbooks and paid attention to the correlation between STEM education and real life. The STEM education in the SACL was more obvious than the Sue version. From the T, E, S, M parts knowledge distribution, Sue's version of textbooks on S dimension coverage was wider than the SACL version, but the emphasis of the two countries was basically the same. Two editions in E, M coverage, were both narrow. Finally, there were some suggestions proposed. STEM education in primary school textbooks should be more explicit, and the amount of STEM knowledge should be increased, especially for the M part [26].

By analyzing and comparing the STEM education path of America, the United Kingdom, and Australia, Feng found that there were some important lessons for China to develop the STEM education, including promoting the top-level design policy of STEM education policy, participating in STEM education sySTEM project with "universal participation", adjusting the educational layout and integrating the formal and informal learning spaces, updating science, technology, engineering, and mathematics curricula, increasing students' learning activities, providing STEM learning and teaching resources, promoting the professional development of schools and teachers [27].

3. CONCLUSION

The subject of this review article was the localization practice of STEM education. The references all came from the CNKI dissertation database. They had been categorized into three aspects: the research and practice of STEM education in European and American countries, the current situation and existing practices of STEM education in Chinese high school, middle school, primary school, and vocational schools and evaluation research.

We could conclude that China is trying to attach more significance to STEM education and drawing important lessons from European and American experiences. Yet, there are still some defects, such as a lack of policies designed for STEM education and attention to gender problems. This paper is helpful for other scholars to understand the specific work of young Chinese scholars in learning and practicing STEM education.

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