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ARTICLE

AN EXPLORATION OF EARLY STEM EDUCATION IN CHINA

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ABSTRACT

This article examines the current state of early childhood education in China, focusing on the high expectations placed on preschool teachers due to cultural traditions, the importance of STEM (Science, Technology, Engineering, and Mathematics) education, and the challenges faced by teachers in effectively teaching STEM subjects. The research highlights the significant pressures on teachers to be infallible and the need for professional development to enhance their efficacy in STEM education. The study also explores contemporary early STEM education practices and policies in China, emphasizing the importance of inquiry-based learning and integrated curriculum to foster young children's curiosity and cognitive development.

KEYWORDS

Early Childhood Education; Early STEM Teaching; Policies; Practices

STEM (Science, Technology, Engineering, and Mathematics) education has become highly valued in early childhood education both in China and globally [1]. This emphasis stems from the recognition that foundational skills in these areas are crucial for the future workforce, given the growing demand for talents and experts in STEM fields [2][3][4]. Early exposure to STEM concepts fosters critical thinking, problem-solving, and creativity, equipping young learners with essential skills for navigating an increasingly complex and technology-driven world. Furthermore, there is widespread enthusiasm for STEM education, driven by the belief that it can stimulate children's natural curiosity and lay the groundwork for lifelong learning and innovation [5].

In China, this enthusiasm is reflected in national policies and educational reforms aimed at integrating STEM into the curriculum from a young age. Similarly, countries around the world are investing in early STEM education to prepare children for future academic and career success. By prioritizing STEM in early childhood, educators and policymakers aim to cultivate a generation of thinkers and innovators capable of addressing the challenges and opportunities of the 21st century.

1. LOW EFFICACY IN STEM TEACHING AMONG EARLY CHILDHOOD TEACHERS

Most early childhood teachers in China were not required to specialize in science during their college education or when applying for preschool teaching positions. Consequently, many educators, including my colleagues, doubt their capabilities in teaching STEM. Some hold a fixed mindset, believing, "I'm not a STEM person," while others question their qualifications, asking, "How can I teach STEM if I wasn't good at it?" and expressing concerns about managing large classes. These doubts and the challenging classroom conditions contribute to low self-efficacy in STEM teaching among preschool teachers all over the world [6].

The anxiety and pressure early educators feel about STEM are understandable. However, relying on performance-based evaluations from the College Entrance Exam to gauge their ability to promote young children's STEM learning is misguided. Poor grades in STEM subjects do not mean a teacher is incapable of supporting early STEM education. Research and teaching practices show that educators can effectively teach STEM with the right support and resources [7]-[10]. Emphasizing continuous professional development and practical teaching strategies can help overcome these challenges and enhance STEM education in early childhood settings.

2. THE CONTEMPORARY EARLY STEM EDUCATION IN CHINA

Science is not just for scientists. STEM actually is for everyone. Appropriate STEM activities boost children's cognitive development at most, for they can use all their senses, motivated by their inborn curiosity and interest to explore materials. By experiment and investigate, they naturally develop understandings about things, such as more/less, far/near and fast/slow, and make more senses of the world gradually [11].

Given the growing needs on early childhood STEM education, the contemporary early teaching or curriculum in China, however, is in need of a reform, which used to be considered as performance-based or spoon-fed which damaging young children's inborn curiosity and self-directed learning motivation [12]. In some preschool curriculum, for example, there can be quite a part focusing on cultivating young children's skills in calculation and rote scientific knowledge, such as addition and subtraction exercises, or reading and reciting scientific facts (such as "when the temperature goes down to zero, water turns

into ice"). Such less developmentally appropriate approaches were hardly inquiry-oriented or integrated STEM, sometimes even beyond children's capabilities [13]. Such phenomena, concluded as primary tendency of preschool education, which indicating that the preschool education principles blurring those of primary school, were strictly banned by the Ministry of Education of the People's Republic of China (2018, July 5).

Compared to the old-fashioned passive learning of preschool children, early STEM education, which emphasizes the fusion of subjects and inquiry-oriented learning activities, seemed to have inherent compatibility with preschool education in China[14] is winning wider and wider popularity ever since the publishment of the Handbook of Children's (3 ~ 6 Years Old) Learning and Development (2012, October 9) (the Handbook), when Science (inquiry) was seriously emphasized as among the five major domains—which referred as Health (including physical and mental well-being), Language and Literacy, Arts (including appreciation and creation of visual art & music), Science (including science inquiry and mathematics) and Social Development of children in preschool. The disciplines of the Handbook reflect not only more comprehensive content in preschool curriculum, but give a highlight on integrated, inquiry-oriented preschool curriculum and teaching (rather than performance-oriented) so as to promote young children's interests and enthusiasm in science, technology, engineering and mathematics [15]. In order to promote children's STEM literacy and cultivate their learning quality [16] it is critical to emphasize integrated STEM curriculum for young children which advocates early childhood educators to understand the meaning, indicators and principles of the five domains [15].

3. POLICIES THAT GUIDE CHINESE EARLY STEM EDUCATION

Given the confusion and the concern over STEM education, studies of *what* and *how* seemed to be crucial. As long as STEM was first announced in the context of America, this project is intended for teachers in China, so the Chinese versions of STEM education or early childhood education would be the major resources to refer to, such like *China's White Paper of STEM Education* (2017) [1]and the *Handbook* (which illustrates principles in different domains such like mathematics and science related areas).

The standards and guidelines of the Handbook are the major ones that well known and widely complied by most Chinese early educators. Among the five domains of the Handbook, the Science part is composed of two subclasses: (1) Science Exploration and (2) Mathematics Cognition. And the Science Exploration subclass consists of three goals for young children's learning and development: (1) Get close to the nature and be willing to explore; (2) Have some basic skills to explore; (3) Understand the surroundings through hands-on exploration. While the Mathematics Cognition subclass consists of the three goals: (1) Find the usefulness and fun in mathematics in daily life; (2) Perceive and understand number, quantity and the relationship between them; (3) Perceive shapes and spatial relationships. The detailed benchmarks of each subclass can be found illustrated respectively from 3-4, 4-5 to 5-6 years old and there followed practical instructions in promoting children's exploration in the subclasses.

4. COGNITIVE THEORIES THAT GUIDE EARLY STEM TEACHING

According to Piaget's Theory of Cognitive Development, children aged 2-7 are in the Pre-operational Stage, where they form ideas based on their perceptions, focus on one variable at a time, and overgeneralize from limited experiences [17]. Despite their cognitive development being less advanced than in later years, early STEM skills and knowledge significantly contribute to later school achievement [18]. Therefore, it is essential for preschoolers to use their innate curiosity, questioning, and exploration skills to understand the world.

Piaget's stage model explains that preschool children in China (ages 2 to 6) develop their understanding through imitation and representative imitation. They form ideas based on perceptions and excel in hands-on activities, which help them develop their schemas of the world [17]. Educators following Piaget's theories believe that children learn how things work through imitation and trial and error. Hence, the best preschool curriculum strategy is to keep children curious and provide real problem-solving opportunities, embodying the hands-on and minds-on approach of early STEM learning.

Vygotsky's learning theory emphasizes the interrelationship between children's social and cognitive development through language [18]. He introduced the concept of the Zone of Proximal Development (ZPD), the gap between what a child can do alone and what they can achieve with help from more knowledgeable peers or adults. Early educators should observe and assess children to identify their ZPD and scaffold their learning through modeling and support to help them progress successfully.

Balancing self-directed play and direct instruction, a concept known as guided play, is crucial for early teaching and learning [19]. Play promotes joyful learning, fostering self-regulation, language, cognitive development, and social-emotional skills while extending content knowledge across disciplines, including STEM. Children learn STEM in an integrated fashion, using their senses to explore and experiment, free from the boundaries between academic areas.

5. CHALLENGES AND STRATEGIES FOR EARLY STEM TEACHING IN CHINA

With the global emphasis on STEM education and the constructive learning trend in early childhood teachers are increasingly developing STEM curricula or incorporating STEM into existing curricula to engage young learners and deepen their interest in STEM [8][20]-[23]. Preschoolers, much like scientists, ask numerous questions about activities and natural events, necessitating that teachers should be well-prepared and competent in guiding STEM-learning activities.

However, many early educators in China lack awareness of STEM principles suitable for preschool curricula. When discussing STEM, they often think of high-tech subjects like robotics and IT, doubting young children's motivation or competency in such activities without solid experiences. Additionally, many report a shortage of STEM resources and materials in schools, and inadequate professional training and support [24]. These issues are common globally, with preschool teachers often unprepared for STEM teaching due to limitations in infrastructure and support systems [25]-[27]. Consequently, teachers may rely on vetted curricular resources or tweak ready-made STEM curricula from online resources [10][24].

By addressing these challenges through continuous professional development and practical teaching strategies, educators can enhance STEM education in early childhood settings, benefiting both teachers and young learners.

6. PRACTICES AND EXPERIENCES IN PROMOTING EARLY STEM TEACHING

Young children construct scientific and mathematical concepts through hands-on exploration with materials that spark their curiosity and discovery [11]. Therefore, educators should carefully design and prepare STEM learning activities, ensuring that materials and environments are adequate and appropriate. To address educators' confusion in promoting early STEM teaching, evaluating preschoolers' learning outcomes properly is crucial. For example, when developing STEM curricula, three levels of learning outcomes should be considered: concepts (standards), essential skills, and habits of mind [5]. During curriculum implementation, productive questioning skills, such as attention-focusing questions, measuring and counting questions, comparison questions, action questions, problem-posing questions, and reasoning questions [28], are widely used to spark children's thoughts and inquiry and guide educators effectively [8][29][30].

In Chinese preschool settings, several models guide early STEM teaching practices. For instance, the four-step model based on Problem-Based Learning has proven helpful in promoting early STEM exploration. This model includes: (1) Establishing a scenario for inquiry, (2) Analyzing and defining problems, (3) Designing and carrying out the inquiry, and (4) Communication and reflection. Rather than performance-oriented traditional rote teaching, STEM learning activities must be developmentally appropriate and quality-oriented. Less structured instruction and center/small group-based inquiries can be more beneficial [22]. Additionally, productive questions have been shown to motivate children's STEM exploration in Chinese settings [15].

Early educators should create a supportive environment, optimize active learning procedures by incorporating comprehensive units, and expand educational channels by proposing productive questions to cultivate children's motivation and learning quality [16][29]. The specific knowledge content for effective STEM teaching includes pedagogical knowledge [7][28], context knowledge [11][31][32] and integration knowledge [33][34]. Practice is crucial for promoting early STEM teaching, as related knowledge and self-efficacy grow through teaching experiences [35][36]. Therefore, reflective coaching and workgroups should be designed and updated based on teachers' needs and feedback.

7. SUMMARY

This thesis explores the state of early childhood education in China, focusing on high expectations for preschool teachers, the importance of STEM education, and the challenges teachers face in teaching STEM subjects. It highlights the cultural pressures on teachers to be infallible and the need for professional development to enhance their STEM teaching efficacy. Effective practices, such as Problem-Based Learning and inquiry-based activities, are emphasized. Policies like China's White Paper of STEM Education and the Handbook of Children's Learning and Development advocate for integrated, inquiry-oriented curricula. Addressing challenges through continuous professional development and practical strategies can enhance early STEM education, benefiting both teachers and young learners.

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