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Research on STEM Activity Designs on the Early Childhood Period in China

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Abstract: *Science, Technology, Engineering, Mathematics(shortened for STEM) education aims to promote learners in academic achievement in the field of Science, Mathematics, Engineering, etc, to promote personal flexible use of disciplines knowledge, skills, problem- solving skills. It is one of the hot topics of basic education reform in the world in recent years. The paper uses the research methods of literature analysis, field interview and questionnaire survey etc. To sum up, three conclusions are drawn, 1) Complete construction of the basic theoretical framework of kindergarten STEM activity design; 2) At the practical level, it systematically proposes the design method of STEM activities in kindergartens, forms a complete system of learning objectives and proposes a specific teaching design model; 3) A relatively complete and comprehensive evaluation method is proposed for the learning effect of STEM activities in kindergartens.*

Keywords: *STEM activity, STEM quality, activity designs, kindergarten*

1. Introduction

In 2017, the China National Institute of Education Sciences successively issued the White Paper on STEM Education in China and the 2029 Innovation Action Plan for STEM Education in China, improving the STEM talent training plan, integrating teaching resources and teachers. As well as the construction of STEM education standards and evaluation systems and other aspects of how to promote China's STEM education, all of which, put forward a comprehensive top-level design plan, the significance of STEM education to "respond to the new economic and social normal demand for talent training direction" height.

STEM education has received global attention.

Many studies have shown that starting STEM education as early as possible yields the best returns and results. The research results in the field of neuroscience and brain research show that 0-6 years old is the fastest stage of individual brain development and nerve growth, during this period, the neurons of the child's brain grow rapidly at a rate of one million per second, and by the end of 6 years old, the establishment of most of the brain nerve pathways has been completed [1]. Children's early experiences have a critical impact on brain development and individual growth, and high-quality STEM learning experiences can provide children with rich opportunities to interact with the environment, peers and adults, and better support children's cognitive and thinking development.

It is in this context that STEM education has become a hot spot in the field of pre-school education China. In 2017, the Chinese Society of Education held a seminar on "Pre-school Education in the context of the Era of Science and Innovation", and STEM education has become one of the main focuses of attention of the participants. Up to now, China's Ministry of Education has paid more and more attention to the development of STEM system in preschool education, and more and more educators are engaged in research in this area.

The specific meaning of kindergarten STEM activity design refers to how to plan and secure the pre-planning of STEM activities organized by teachers and related external events according to the concepts of STEM education and preschool education [2]. It includes analyzing children's learning needs, setting STEM activity goals, organizing learning situations, arranging and adjusting learning activities, etc., to support and promote kindergarten children's STEM learning.

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2. Design content arrangement of STEM activities

2.1 Taylor's Principle provides a concise and clear theoretical framework for the design of STEM activities in kindergartens

Taylor principle divides the curriculum into four elements of "goal - content - implementation - evaluation", which provides a complete, systematic and operable development model for kindergarten education activity design [3]. The theoretical framework design as is shown in Figure 1.

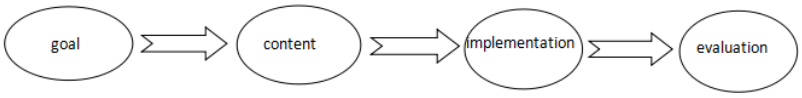

Figure 1: Theoretical framework of STEM activity design

2.2 Research ideas and overall framework

"Great Wall Builders" as the theme of the learning task design: the activity is divided into four units, namely, the design of the Great Wall, the construction of the Great Wall, the trial operation of the Great Wall and the Great Wall Open Day. The first unit "Designing the Great Wall" adopts the method of collective teaching. Teachers introduce the historical background and geographical environment of the Great Wall and other basic information, stimulate children's desire to participate in the construction of the Great Wall, and clarify the driving problem of the activity: "How to design and build a Great Wall with new functions". Then, the children are divided into several groups in the form of free groups. Members of each group read picture books related to the Great Wall, observe pictures of the Great Wall, understand the role, structure, shape and features of the Great Wall, then discuss the theme and function of the Great Wall to be designed, and draw design blueprints.

The learning task design drawing of "Great Wall Builder" is Figure 2 as follows:

Unit	Engineering Design Process	Content	Teaching Style	Time Arrangement
Designing the Great Wall	Identifying problems	Set up a context so as to develop students Construction capacity; Arouse the interest to the Great Wall; Understand the purposes to build up the Great wall.	collective teaching	40 minutes
	Setting targets	Identify the needy objective,that is to build up a Great Wall with new functions.		
	Designing Plans	Determine the materials we can use;Discuss the different schemes to build up a new one; Draw its designed pictures.		
Building the Great Wall	Building-up and Tests	According to the schemes ,students accomplish it cooperatively in small groups.	Individualized activities	40 minutes once, altogether 12 times
Trial Operation of the Great Wall	Optimization and improvement	Test the function of the built-up Great Wall; Search out the deficiencies and problems in designing and building up; on the basis of the results, modify or rebuild the Great Wall.	Individualized activities	40 minutes once, altogether 3 times
Opening Day of the Great Wall	Communication and Sharing	Present the finished masterpiece to other students, introduce the characters of designing and making ;Evaluate other groups masterpieces.	collective teaching	40 minutes

Figure 2: The Great Wall Architect Learning Design

In the first unit "Designing the Great Wall", the teacher introduced the historical background and geographical environment of the Great Wall and other basic information, so as to stimulate children's desire to participate in the construction of the Great Wall, and clarify the problem : "How to design and build a Great Wall with new functions". Then, the children are divided into several groups in the form of free groups. Members of each group read picture books related to the Great Wall, observe pictures of the Great Wall, understand its role,structure and shape features, and then discuss the theme and function to be designed, and draw design drawings.

In the second unit, "Building the Great Wall", each team collected the materials needed to build the Great Wall according to the design plan, and carried out the production of the Great Wall. "Building the Wall" takes the form of individual activities lasting two to three weeks.

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After the completion of the task of building the Great Wall, the third unit activity, "The Great Wall Trial Operation", was carried out, and each group assigned a team member to test the works of the four groups, including testing the stability by touch, testing the functionality by simulated use, and evaluating its appearance by observation. After showing the Great Wall built, ask the children visit the Great Wall built by various groups. In the experiment, through the trial operation, the children can find the problems of their own construction, and also get inspiration from the Great Wall built by other groups. According to the results of the trial operation, each group modified and improved the Great Wall they built.

In the fourth unit, "The Great Wall Open Day", the children will officially display the modified and optimized Great Wall to the class, and the group members will introduce and show the design characteristics of their works to the class, and other children and teachers will comment on the group's works.

3. Design of learning assessment

According to the learning goal set by the Great Wall Architect activity, the corresponding evaluation method is designed. For example, STEM skills such as explanation, expression, communication, concentration and persistence are mainly assessed by participants observation in the classroom. The structure and function of STEM knowledge concept, creativity, and learning quality are integrated by various assessment methods such as children's interview, classroom observation and masterpiece analysis [4] . The specific evaluation design is shown in Figure 3 below:

STEM Qualifications in Early Childhood Education	Learning Goals	Evaluation Methods
STEM Knowledge	Construction and Function :In designing of the Great Wall,it is recognized that the construction and function of buildings are have a close connection between them.	Children Interview; Observation in Class; Masterpieces Analysis.
	Geometry Graphics:It is found that there are some geometry graphics on the Great Wall .We can build it up by using the rectangular and square materials.	Children Interview; Observation in Class; Masterpieces Analysis.
STEM Skills	Observation	Observe carefully in designing and making of the Great Wall, then, find out its characters.
	Problems and Goal	Identify its goals and solve needy problems.
	Explanation and Expression	Use language,drawings,and models to show your own design and your masterpiece's characters.
	Planning and Design	Use drawings,symbols and other methods to finish your masterpiece's design.
	Communication	During the activity,communicate with your partners positively.
	Execution	According to the design scheme to finish the making of the Great Wall.
STEM Learning Quality	Perseverance	Show strong concentration and perseverance during the process of designing and building-up.
	Cooperation	Cooperate with partners to build up the Great Wall.
	Creativity	Try out to use different materials and methods when children build up the Great Wall.

Figure 3: The Great Wall architect learning assessment design

4. Discussion

This study focuses on "How should STEM activities in kindergartens be designed?" This core issue is studied from three aspects, including: at the theoretical level, the basic theoretical framework of kindergarten STEM activity design is completely constructed; At the practical level, the design method of STEM activities in kindergartens is put forward systematically, including constructing a complete system of learning objectives and putting forward a concrete teaching design model. Furthermore, a more complete and comprehensive evaluation is made on the learning effect of STEM activities in kindergartens [5]. This paper focuses on the theoretical framework, design method and learning effect of STEM activities in kindergarten. There are preliminarily obtained some research results in this study, which are summarized as follows:

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4.1 Analyze and explain the four major elements of STEM activities in kindergartens: objectives, content, implementation and evaluation

The activity goal is to cultivate children's early STEM quality . This study proposed the concept in early childhood for the first time and defined it: "The child's initial knowledge of concepts and process methods related to the four disciplines of science, technology, engineering and mathematics, and the ability to apply them to understand and identify problems relevant to the child, design solutions to these problems, and develop active exploration, from the moment of birth until the beginning of the formal study of science, mathematics and other subjects [6,7]. Positive mental tendencies such as perseverance and bold creativity, and identified it as the overall goal of STEM activities in kindergartens.

It clarifies the core elements of implementation on the activity-- integration, and explains that STEM activities in kindergartens should have the complementary features of different types of kindergarten education activities through the organic combination of high-structure and low-structure activities, game activities and teaching activities, so as to ensure that children's STEM learning process is full of the joyful spirit. It also has clear learning and development goals [8] .

The performance evaluation is determined as the guiding concept of activity evaluation, and it is proposed that activity evaluation should focus on the learning performance and development of STEM knowledge, STEM skills and STEM learning quality in children's STEM activities [9] .

4.2 The proposal of kindergarten STEM activity design methods

This study divides the research on the design methods of STEM activities in kindergartens into two parts. First, through the research and construction of children's STEM learning goal system -- children's early STEM quality index system, it lays a foundation for the content selection, strategy design and evaluation planning of kindergarten STEM activity design [10]. Then, the teaching mode of STEM activities in kindergartens is proposed to a set of specific, systematic and operable teaching organization style and implementation process for the design activities.

The teaching process of ED-ES teaching mode is divided into five main steps, which are clarifying the problem, designing the scheme, making and testing, optimizing and improving, and communicating and sharing [11]. The five steps are closely focused on the objectives of engineering design. In all aspects of teaching activities, teachers should pay close attention to children's learning performance and behavioral feedback, and take flexible measures to provide students with diversified learning scaffolds to promote children's competences on independent exploration and problem solving [12]. American scholar (Anne Jolly) proposed the Engineering Designing process,Figure 4 is as follows:

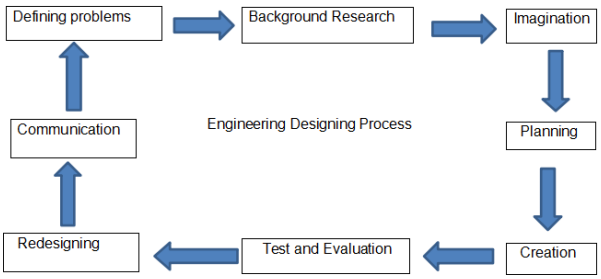

Figure 4: Science and technology engineering designing process

4.3 Evaluation of the learning effect of STEM activities in kindergartens

Based on the concept of performance assessment, this study collected evidence of children's learning performance in three rounds of STEM teaching activities through interviews, classroom observation and masterpiece analysis, and investigated the learning effect of STEM activities in kindergartens [13,14] . The results show that STEM activities in kindergarten can significantly improved. children's level of STEM skills in observation, problem and goal, interpretation and expression, communication and cooperation. Data analysis showed that children's STEM skills development significantly improved between the first round of activities and the second round of activities, as well as between the first and third rounds of activities, while children's STEM skills gradually increased between the second and third rounds of activities.

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5. Conclusions

1) Further application, verification and improvement of the theoretical framework of STEM activities and ED-ES teaching mode in kindergartens. In this study, the concept, goal, content, implementation and evaluation of STEM activities in kindergarten, as well as the ED-ES teaching model were comprehensively explained and constructed. In future studies, STEM activities in kindergartens with different themes and types can be designed and developed based on the theoretical framework and teaching mode, and according to the school-running characteristics of different kindergartens, so as to verify the applicability of the theoretical framework of activity design and teaching mode proposed in this study. In the future, we will further improve and optimize the theoretical framework of activity design and ED-ES teaching model.

2) Research on STEM activities development in kindergartens. This study systematically and completely put forward the target system of early childhood STEM learning - the index system of early childhood STEM literacy. In future studies, kindergarten STEM activity resources with diverse themes can be designed and developed according to the children's STEM learning objectives and learning content proposed by this index system, so as to provide strong supports for the implementation of STEM education in kindergartens.

3) Research on the impact of STEM learning in kindergarten on children's future academic performance and development. Foreign studies have shown that STEM learning can have a certain impact on children's academic performance and comprehensive development in science, mathematics, language expression, academic interest and other aspects in primary school and even junior middle school. However, there are not many related researches in China. In the future, based on the research results of this study, the standardized design of STEM activities in kindergartens and the continuous implementation of STEM learning can be carried out, such as the assessment of children's relevant ability after entering primary school, and the long-term impact of STEM learning in the Early Childhood stage on children's future academic achievement and various aspects of development can be studied.

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