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The Effectiveness of Online vs. Traditional STEM Education Methods for Preschool Children Aged 5-6 years in China

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Abstract: This study explores the effectiveness of online vs. traditional STEM education methods for preschool children aged 5-6 years in China. Through qualitative interviews with educators, this study compares how these methods affect children's engagement and learning outcomes. The findings suggest that traditional hands-on approaches are more effective in engaging younger learners due to the importance of sensory and social experiences in early cognitive development. While online platforms offer personalized learning, they often struggle to maintain long-term engagement. The study highlights the need for a hybrid approach that combines the strengths of traditional and digital methods to optimize STEM education. In addition, the study explores the challenges of the digital divide and the importance of equitable access to technology. These insights provide practical recommendations for improving early STEM education practices and guiding future policy decisions.

Keywords: STEM Education; Engagement; Technology; Early Cognitive Development.

1. Introduction

1.1. Research Background

Early childhood education plays a crucial role in cognitive development, laying the foundation for future academic success and lifelong learning. During this critical period of development, science, technology, engineering, and mathematics (STEM) education is receiving increasing attention for its potential to cultivate critical thinking, problem-solving skills, and curiosity in young children. Early exposure to STEM concepts is considered key to preparing children for the challenges of a rapidly developing technology driven world. Therefore, incorporating effective STEM education into early childhood curricula has become a focus for educators and decision-makers worldwide.

In recent years, the rise of digital learning platforms has opened new possibilities for providing STEM education. Online education provides unique advantages such as personalized learning paths, flexible resource access, and the ability to integrate multimedia elements that enhance understanding. These tools are particularly attractive in early childhood education, where interactive and visually stimulating content can capture the attention of young learners. However, despite these potential benefits, there is still considerable debate about the effectiveness of online education for preschool children, who are in a developmental stage where hands-on, sensory experiences are crucial for learning. Research in this field is still limited, especially in understanding the comparison between digital tools and traditional, hands-on teaching methods in cultivating participation and learning outcomes in STEM subjects.

In the context of China, early childhood education has undergone significant reforms, with increasing emphasis on STEM subjects as part of the national curriculum. The rapid technological progress in China has further accelerated the integration of STEM education into various levels, including preschool education. However, like other regions in the world, the implementation of STEM education in Chinese kindergartens faces challenges, especially in balancing the use of traditional and digital teaching methods. Traditional STEM education in China typically involves teacher led teaching, group activities, and the use of physics materials to help children explore scientific concepts. In contrast, the use of digital tools, although increasingly popular, is still relatively new and raises questions about their effectiveness in the context of sensory and social learning being highly valued. In addition, the outbreak of the COVID-19 pandemic in 2019 further complicated the situation as many schools were forced to switch to online learning, including early childhood education. This sudden shift highlights the potential and limitations of online education for young learners. Although some children have adapted well to the digital learning environment, others are struggling, especially in families with limited access to technology or insufficient support from parents. These differences raise important questions about the role of online education in early childhood education and its ability to serve as a fair solution in different socio-economic contexts.

Based on these considerations, this study aims to explore the effectiveness of online and traditional STEM education methods for preschool children in China. Specifically, it aims to investigate how these teaching methods engage young learners in STEM subjects and identify any key differences in their impact on 5-6 years old children. By addressing these issues, this study contributes to the growing literature on early childhood education and provides practical insights for educators and decision-makers seeking to address the challenges of integrating digital tools into early STEM education.

1.2. Research Topic

Based on the above background, this study aims to explore the effectiveness of online and traditional STEM education methods for preschool children aged 5-6 in China. Specifically, this study will investigate two main questions: (1) In what ways, if any, do online or traditional teaching methods better engage preschool children in STEM learning attending kindergarten in China? (2) In what ways, if any,

do online or traditional STEM teaching methods differ among children aged 5-6 attending kindergarten in China?

By comparing these two educational methods, this study aims to provide insights on how to optimize early STEM education to support the participation and understanding of young learners. These findings aim to contribute to the ongoing discussion on integrating digital tools into early childhood education, while addressing the unique challenges faced by educators in balancing online and practical learning experiences. Through this comparative analysis, this study will provide practical recommendations for improving the implementation of STEM education in Chinese kindergartens and have a broader impact on global educational practices.

1.3. Research significance

This study contributes to the academic field of early childhood education by addressing several key gaps in current literature, particularly regarding the integration of STEM education in the preschool stage. Despite extensive research on the benefits of hands-on experiential learning in STEM education for young children, the effectiveness of online teaching methods for this age group has not been fully developed. Given the increasing reliance on digital learning platforms, especially after the COVID-19 pandemic in 2019, this study timely examines the comparison between online STEM education and traditional methods in attracting young learners.

By investigating the impact of these two educational methods on preschool children aged 5-6, this study contributes to the ongoing academic debate on the role of digital tools in early education. Specifically, it provides insights into whether online platforms can effectively replicate or enhance learning outcomes typically associated with hands-on STEM activities. The study also addressed the developmental suitability of digital learning for young children, a topic that has been a subject of considerable debate among educators and researchers. Through this analysis, the study helps clarify under what circumstances online education can be beneficial for preschool children and provides a more nuanced understanding of how to combine traditional and digital methods to optimize early STEM education.

In addition, this study fills a key research gap in the context of early childhood education in China, where STEM education is increasingly valued, but the integration of digital tools is still in its early stages. By focusing on the Chinese kindergarten system, this study extends the global understanding of early STEM education to less explored contexts, contributing to a broader understanding of how culture and education systems influence the effectiveness of various teaching methods.

1.4. Paper Structure

This paper presents a study on the effectiveness of online and traditional STEM education methods for preschool children in China, with a focus on how these methods attract 5-6 years old children and explore the differences in their impact on learning outcomes. This article is divided into six chapters, namely Introduction, Literature Review, Research Methods, Results and Analysis, Discussion and Conclusion, each chapter covering different aspects of the research. By organizing the paper in this way, this study is presented in a logical and coherent order, allowing readers to track the progress of the research, considering methodology, research results, as well as the impact of practice and future research from the initial background and theory.

2. Organization of the Text

2.1. Methodology

This chapter aims to introduce the research design, participant selection, data collection and analysis methods, as well as ethical considerations of this study. This chapter will provide a detailed description of the specific methods used in the research process, ensuring that readers have a comprehensive understanding of the research process and thus understand the credibility and effectiveness of the research results. The following sections will sequentially introduce the design framework of this study, recruitment and selection criteria for participants, data collection tools and methods, data analysis techniques, and ethical considerations.

2.1.1. Philosophical Stance

This study adopted the philosophical positions of constructivism and interpretivism. Constructivism is a perspective that holds that knowledge is jointly constructed through interactions between individuals and their understanding of the world. Contrary to objectivism, constructivism holds that there is no objective reality independent of human experience. On the contrary, knowledge and meaning are generated through people's interactions within social and cultural contexts. For this study, the constructivist stance means that I focus on how teachers and students construct their understanding of the effectiveness of STEM education through interaction and experience in specific educational contexts (Berger&Luckmann, 1967). Interpretivism is a method of acquiring knowledge through a deep understanding of the subjective experiences and meaning constructions of individuals and groups in specific contexts. Interpretivism emphasizes understanding the intrinsic meaning of human behavior, rather than just observing and describing external behavior. It focuses on how people interpret and give meaning to their experiences, and how they construct their reality through these meanings (Schutz, 1967).

By adopting the philosophical positions of constructivism and interpretivism, this study can delve into the experiences and perspectives of educators and students in different STEM education methods, providing valuable insights for educational practices and policies. There are several reasons why this study chooses the philosophical positions of constructivism and interpretivism. Firstly, it is suitable for the research objectives. The aim of this study is to explore and compare the effectiveness of online and traditional STEM education methods in attracting preschool children aged 3 to 5. Constructivism and interpretivism emphasize understanding participants' subjective experiences and meaning construction, which is in line with research objectives. Through this approach, research can gain a deeper understanding of how teachers and students experience and understand different STEM education methods in specific educational contexts.

Finally, this study took a constructivist and interpretive philosophical stance and aimed to gain a deeper understanding of preschool teachers' experiences and perspectives on different STEM education approaches. This approach emphasizes the subjective experiences of educators and students, capturing their complex understanding of the effectiveness of online and traditional STEM education

through qualitative research methods. Specifically, this study sought to answer the following research questions: (1) In what ways (if any) do online or traditional teaching methods better engage preschoolers in STEM learning? (2) What are the key differences in the effectiveness of online and traditional STEM teaching methods for children ages 5-6?

2.1.2. Research Methods

This study employed qualitative research methods. Qualitative research method is a research approach used to explore and understand people's attribution of meaning to social or human issues. This method emphasizes individual subjective experiences and interactions within social contexts, typically collecting data through in-depth interviews, observations, and text analysis. Qualitative research methods focus on the deep understanding and interpretation behind complex phenomena, rather than quantification and statistical analysis (Creswell, 2013).

The specific reasons for choosing qualitative research methods in this study are as follows: firstly, the main purpose of this study is to explore and compare the effectiveness of online and traditional STEM education methods in attracting preschool children. Qualitative methods are particularly suitable for exploratory research, with the goal of gaining a deeper understanding of participants' experiences and perspectives. Through in-depth interviews, research can reveal subtle differences in how educators perceive and implement these educational methods, which may not be captured through quantitative measurements (Merriam, 2009). The flexibility of qualitative methods allows researchers to adjust questions based on the progress of the interview, which is key to capturing the depth and richness of participants' responses. Secondly, qualitative research emphasizes the importance of context, which is crucial for understanding the educational environment and its impact on STEM learning. By focusing on the specific contexts in which online and traditional STEM education operates, research can gain a more comprehensive understanding of how these methods affect student engagement and learning outcomes (Yin, 2018). Studying in the natural environment of interaction between educators and students can provide a more authentic and comprehensive understanding of the educational process and outcomes.

By adopting qualitative research methods, this study can delve into the experiences and perspectives of educators and students in different STEM education methods, providing valuable insights for educational practice and policy. Meanwhile, by taking measures to address the challenges and limitations of qualitative research methods, the credibility and effectiveness of research results can be ensured.

2.2. Data Collection

This study used semi-structured interviews as the main data collection method. Semi structured interviews are a flexible data collection method that includes both predesigned question frameworks and allows interviewers to ask impromptu questions and engage in in-depth discussions based on the progress of the interview. Compared to structured interviews, semi-structured interviews have greater flexibility in capturing detailed perspectives and complex experiences of the interviewee (Creswell, 2013). The advantage of semi-structured interviews lies in their ability to delve into complex topics and capture detailed perspectives and emotions of the interviewee (Smith&Osborn, 2003). Through flexible questioning, interviews can generate rich and diverse data, which helps to gain a deeper understanding of the interviewee's experiences (Gill et al., 2008). During the interview process, questions can be clarified in a timely manner to ensure the accuracy and reliability of the data (Berg, 2009).

There are several reasons for choosing semi-structured interviews in this study. Firstly, semi-structured interviews allow researchers to ask questions and explore in depth based on the responses of the interviewees during the interview process, thereby obtaining richer and more detailed information (Bryman, 2016). This method can capture the complex perspectives and detailed experiences of respondents, which helps researchers to gain a deeper understanding of their experiences and perspectives. This is crucial for exploring educators' views and experiences of different STEM education methods (Kvale, 2007).

2.3. Data Analysis

This study adopted thematic analysis as the main data analysis method. Thematic analysis is a method used to identify, analyze, and report patterns (themes) in qualitative data. It systematically encodes data to discover and describe recurring themes in the data, thereby helping researchers understand the main ideas and meanings in the data. Thematic analysis can be applied to a wide range of research questions and data types and is a flexible and widely used qualitative data analysis method (Braun&Clarke, 2006).

Thematic analysis can help identify and understand the main patterns and themes in exploring educators' and students' perspectives and experiences of different STEM education methods. The thematic analysis method also has systematicity and transparency, providing a systematic approach to processing and analyzing data, ensuring a structured and orderly analysis process (Braun&Clarke, 2013). Through clear steps and processes, thematic analysis makes the data analysis process transparent and reproducible, which helps to improve the credibility and reliability of research (Maguire&Delahunt, 2017).

2.4. Sampling and Sample

This study used purposive sampling. Purposive sampling is a non probability sampling method in which researchers intentionally select individuals or groups that can provide rich information and insights based on research objectives and specific criteria. The goal of purposive sampling is to select typical cases that best represent the research problem or phenomenon, rather than pursuing sample randomness (Patton, 2002).

The advantage of purposive sampling is that it can select participants who are most likely to provide profound insights and detailed information, which helps to gain a deeper understanding of the research question (Creswell&Plano Clark, 2017). For this study, purposive sampling was chosen, selecting preschool education teachers with online and traditional STEM education experience as samples, which can directly obtain comparative insights about the two educational methods and help achieve the research objectives. Purposive sampling is more efficient than random sampling and can collect valuable data within limited time and resources (Merriam&Tisdell, 2016). By selecting participants with rich information, researchers can gain profound insights and detailed data in smaller samples, thereby improving the depth and quality of the study (Patton, 2002).

Through the above sampling process and sample selection,

this study was able to collect high-quality data that is highly relevant to the research question within limited time and resources, providing a solid foundation for achieving the research objectives.

2.5. Ethical Considerations

The ethical issues involved in this study include ethical approval, participants' right to know, anonymity, and confidentiality. The following are specific measures taken in each aspect of this study to alleviate or address these ethical issues.

Before starting data collection, the study will submit a detailed research plan to the ethics review committee of the relevant institution, including research objectives, methods, potential risks and benefits, participant protection measures, etc. Strictly follow the guidelines and requirements provided by the ethics review committee to ensure that the research design complies with ethical standards. During the research process, regularly report research progress and any potential ethical issues to the ethics review committee to ensure transparency and compliance of the research process. Participants have the right to be informed, and they have the right to fully understand the purpose, procedures, potential risks and benefits of the study, as well as their rights in the study, including the right to withdraw from the study at any time.

3. Results and Analysis

This chapter presents qualitative research findings gathered through semi-structured interviews. The analysis is organized around key themes distilled from the data that reflect preschool educators' perceptions of the effectiveness of online and traditional STEM education methods in engaging preschool children. Using thematic analysis methods I examined participants' subjective experiences and observations in detail, providing insight into the relative effectiveness of these educational methods.

A total of 8 semi-structured interviews were conducted with preschool teachers with extensive teaching experience. These teachers had hands-on experience in online and traditional STEM education and were able to provide valuable comparative insights for this study. Participants' backgrounds included different types of preschool institutions, such as public kindergartens, private schools, and community education centers. Their teaching experience generally exceeded 5 years, and some participants also had specialized knowledge of educational technology.

Interviews were conducted during July 2024 in the form of face-to-face interviews, telephone interviews and video conferences. Interview locations were chosen according to the convenience of the participants, and as far as possible in their familiar and comfortable environment to ensure the authenticity and validity of the data. These interview data were analyzed through thematic analysis, and the following themes and sub-themes emerged in the data:

Theme 1: The effectiveness of educational methods

Sub-theme 1.1: Enhancing child engagement

Sub-theme 1.2: Differences in learning outcomes

Theme 2: Challenges and obstacles in implementation

Sub-theme 2.1: Availability of technical resources

Sub-theme 2.2: Access to teaching resources

Theme 3: The role of teachers and professional development

Sub-theme 3.1: Professional knowledge and skills of teachers

Sub-theme 3.2: Teachers' adaptation and feedback to different teaching methods

Theme 4: The impact of parental involvement

Sub-theme 4.1: Parental support in online learning

Sub-theme 4.2: The role of parents' participation in traditional classrooms

Traditional STEM education methods promote children's in-depth participation and conceptual understanding through hands-on, experimental activities, as well as face-to-face interactions. These methods, with their dependency on concrete physical materials and real-time teacher guidance, can visually present abstract STEM concepts. According to Piaget's constructivist theory, children construct their own knowledge structures through direct interaction with the environment. Therefore, hands-on and experimental activities are particularly valid in helping children understand sophisticated scientific and mathematical concepts. Participatory learning styles, such as experiments and exploratory activities, can stimulate children's curiosity, enabling them to apply and consolidate the knowledge they have learned in practice. However, online STEM education tools offer irreplaceable advantages in specific contexts. First, online tools can personalize learning content and pace to suit different children's learning speeds and styles. Second, online platforms provide rich multimedia resources such as animations, interactive games, and virtual labs that vividly demonstrate concepts that are difficult to delineate through traditional methods. In addition, online education can also provide continuous learning resources after school to help children consolidate the knowledge learned in the classroom.

Online STEM education faces the challenge of insufficient access to technical resources in the implementation process, while traditional STEM education is constrained by limited teaching resources. Both methods have practical obstacles in different settings. In online STEM education, the availability and quality of technical resources are key factors affecting their effectiveness. The problem of digital divide, especially in low-income families or remote areas, severely restricts children's access to online learning resources. Even in well-resourced settings, online learning requires active participation and supervision from parents, as preschool children often lack self-discipline and technical skills to complete online courses independently. This dependency increases the burden on parents and limits the effectiveness of online education to a certain extent. In addition, the quality of online educational platforms and tools also has a significant impact on learning outcomes. Low-quality or inappropriate digital content can distract children's attention and even mislead their learning direction.

The role of the teacher in STEM education is crucial, especially when delineation of complex concepts and guiding inquiry learning. The professional competence of the teacher directly affects the learning outcomes of the students. To adapt to evolving educational technologies and teaching methods, teachers need continuous professional development and training. This includes not only the use of technological tools, but also how to effectively integrate these tools into teaching.

In online STEM education, parental involvement is essential for children's learning. Since preschoolers have limited autonomous learning abilities, they need parents to provide guidance and support during the learning process. In contrast, in traditional classrooms, teachers take on more

mentoring responsibilities, but parental support remains an important factor in a child's success.

Through thematic analysis, four main themes were identified by consensus: 1. Engagement and Participation: Different engagement of preschool children in online versus traditional STEM education. 2. Learning Outcomes and Understanding: Differences between the two approaches in terms of learning outcomes and depth of understanding. 3. Challenges and Barriers: Barriers encountered in implementing online versus traditional STEM education approaches. 4. Role of Educator and Parent Involvement: Importance of Teacher Guidance and Parent Involvement in Supporting Children's STEM learning.

This chapter reviews and answers the key research questions in this study, namely, "To what extent do online or traditional teaching methods better engage Chinese preschoolers in STEM learning?" and "What are the differences in the application of online or traditional STEM teaching methods among Chinese preschoolers aged 5-6?" Through a detailed discussion of systematic literature analysis and semi-structured interview data, this chapter explores the relative effectiveness of these two educational methods in different settings and the main challenges and barriers to implementation.

4. Discussion

The aim of this study is to compare the effectiveness of online and traditional STEM education in improving the participation and learning outcomes of preschool children aged 3-5. Adopting a qualitative research methodology, including interviewing experienced preschool teachers, to gain a deeper understanding of the practical application of the two educational methods. The main findings indicate that traditional STEM education, especially through hands-on activities, is highly effective in increasing children's participation and understanding. Meanwhile, online education provides personalized learning resources and multimedia tools to support students with different learning rhythms. The following discussion will delve into these findings, discuss the relationship between the results of this study and existing literature and relevant theoretical models, as well as discuss unexpected or unexpected discoveries, and finally elaborate on the shortcomings of this study.

There are several possible reasons to explain this inconsistency. One possibility is parental involvement: the effectiveness of online STEM education may be greatly influenced by the level of parental support, especially for young children who have not yet learned independently. Although Neumann and Neumann (2014) hypothesized a high level of parental involvement, the situation encountered in this study was that parents were either not present or lacked the technological capabilities to support their children's online learning. This difference suggests that the success of online STEM education in early childhood may be more dependent on the environment than previously thought, highlighting the crucial role of parental involvement in this learning environment. Another potential explanation for the inconsistency is that different socio-economic groups have varying degrees of access to technology and digital literacy. Plowman et al. (2012), unequal access to digital resources creates a digital divide that may hinder the effectiveness of online learning (results and analysis). In this study, teachers reported that children from low-income families have difficulty accessing necessary technology, which affects their ability to fully participate in online STEM activities. This can explain why in some cases, the effectiveness of online education is not as expected. The third reason for inconsistency may lie in the developmental stage of preschool children. Although online education has been proven effective for older children who can participate more independently in digital content, preschool children may still heavily rely on tactile and sensory experiences for learning, as suggested by Vygotsky's theory of social development (Vygotsky, 1978). This reliance on physical interaction with the environment may limit the effectiveness of pure online education methods for this age group, as they are not yet ready to fully benefit from abstract, screen based learning in their development.

In summary, although the results of this study are consistent with many existing early childhood STEM education literature, particularly emphasizing the value of hands-on learning and personalized online resources, the observed inconsistencies suggest that background factors such as parental involvement, technology acquisition, and developmental readiness play a key role. These research findings emphasize the importance of adopting a meticulous approach to STEM education for early childhood, and by carefully considering these influencing factors, the advantages of traditional and online methods can be maximized.

traditional STEM education methods. Although efforts have been made to triangulate the data with existing literature, the conclusions of this study can benefit from additional observational data or objective measures of student engagement and learning outcomes. Future research can address this limitation by adopting mixed methods, including direct classroom observation or evaluation of student performance.

In summary, while this study provides valuable insights into the comparative effects of online and traditional STEM education on preschool children, it is also important to recognize its limitations. The relatively small sample size, limited background and resources, and reliance on self-reported data all pose challenges to the universality and comprehensiveness of research results. These limitations highlight the necessity for future research to address these issues and further explore the complex interplay between educational methods, resource availability, and long-term learning outcomes in early childhood STEM education.

5. Literature Review

Research has shown that early childhood is a pivotal period for cognitive, social, and emotional development (Piaget, 1952; Vygotsky, 1978). During these formative years, children are naturally curious and eager to explore the world around them. STEM education leverages this curiosity by providing hands-on, inquiry-based learning experiences that encourage children to ask questions, experiment, and develop a deeper understanding of scientific and mathematical concepts. This early engagement with STEM can lay the groundwork for a lifelong interest in these fields and better prepare children for future academic and career opportunities (Brenneman, Stevenson-Boyd, & Frede, 2009). Moreover, STEM education in early childhood can help to address the gender and socioeconomic disparities that often exist in STEM fields (National Science Foundation, 2020). By introducing STEM concepts at a young age, educators can foster an inclusive environment that encourages all children, regardless of their background, to pursue and excel in STEM-

related activities and studies. The integration of technology in education has transformed traditional teaching methods and opened new avenues for learning. Online education has seen significant growth, driven by advancements in digital technology and the increasing availability of internet access (Means, Toyama, Murphy, Bakia, & Jones, 2010). This shift has been further accelerated by the COVID-19 pandemic, which necessitated the adoption of remote learning solutions to ensure educational continuity (Dhawan, 2020).

For preschool education, online platforms and digital tools offer unique opportunities to enhance STEM learning. Interactive apps, virtual labs, and educational games can provide engaging and personalized learning experiences that are difficult to replicate in a traditional classroom setting (Hirsh-Pasek et al., 2015). These tools can cater to individual learning paces and styles, making STEM education more accessible and enjoyable for young children.

By achieving these goals, this literature review will provide valuable insights into the effectiveness of STEM educational approaches for young learners and provide educators and policymakers with information on how to optimize instructional strategies to support early STEM learning.

5.1. Research Status

Regarding the definition of traditional STEM education, Alade (2016) suggests that it is typically conducted in a classroom environment, emphasizing face-to-face interaction and hands-on activities. This method includes direct instructor guidance, physical manipulation of materials, and collaborative learning experiences, aiming to promote a deeper understanding of STEM concepts through experiential learning.

The study by Brenneman et al. (2009) supports the importance of practical and exploratory learning in early childhood education and emphasizes its role in cultivating critical thinking and problem-solving skills. Wan et al. (2021) reviewed empirical research on early childhood STEM education and pointed out that traditional hands-on methods effectively attract preschool children by encouraging their active participation and exploration. Schweingruber et al. (2014) also explored the status and prospects of STEM integration in K-12 education. They emphasized the importance of hands-on learning in early education, emphasizing that direct interaction with materials and physical contact can help better understand and retain STEM concepts.

Brenneman et al. (2009) argue that face-to-face teaching allows for immediate feedback and personalized teaching, meets individual learning needs, and promotes more targeted teaching methods. Through practical operation of materials, it is crucial for children to understand abstract concepts through concrete experiences, which is crucial for their cognitive development. In terms of group activities and collaborative projects, promoting social skills and teamwork is an important component of comprehensive STEM education. These experiences help children learn to communicate collectively, share ideas, and solve problems.

5.2. Key Factors Influencing Engagement in STEM Education

Among child centered factors, cognitive development significantly affects the participation and understanding of STEM concepts by preschool children. According to Piaget&Cook's cognitive development stage, preschool children are in the preoperative stage, characterized by symbolic thinking and limited logical reasoning (Piaget&Cook, 1952). This stage benefits from specific hands-on activities that allow children to manipulate objects and directly observe the results. Children have different learning styles and preferences, which affect their participation in STEM activities. Hirsch Pasek et al. (2015) emphasized the importance of a multimodal learning environment that satisfies these different preferences. The second factor is educational content and design, and integrating STEM concepts into daily activities can make learning more relevant and attractive to preschool children. Effective curriculum design incorporates STEM in a way that is relevant and exciting for young children. For example, integrating STEM courses into daily activities can help children understand the practical application of these concepts and cultivate deeper interest and understanding. The third factor is technological factors, and obtaining technology will significantly affect the effectiveness of online STEM education. Plowman et al. (2012) discussed the impact of the digital divide on early childhood education. Inequality in accessing technology may pose obstacles for some children. Ensuring that all children have access to necessary digital tools is crucial for fair STEM education. The quality of digital tools and resources plays an important role in their effectiveness. Hirsh Pasek et al. (2015) emphasized the necessity of designing educational applications based on the principle of effective learning. High quality digital tools should be interactive and attractive to attract the attention of young learners.

5.3. Theoretical Framework

Firstly, constructivist theory emphasizes the process of learners actively constructing new knowledge based on existing knowledge. Piaget and Vygotsky believe that children learn through interaction with the environment, which supports the use of hands-on activities and interactive digital tools in STEM education. These methods can stimulate children's exploratory and creative thinking. Piaget's theory suggests that children learn by actively exploring and manipulating specific objects. Hands on activities and interactive learning environments can help children better understand abstract STEM concepts (Piaget&Cook, 1952). Kamii and DeVries (1978) emphasized the importance of the Piaget method in promoting cognitive development in their research on early childhood education. Vygotsky emphasized the importance of social interaction in cognitive development and proposed the concept of a zone of proximal development. He believes that under the guidance of knowledgeable individuals, children can achieve greater success. Collaborative learning and teacher guidance are crucial in STEM education (Vygotsky, 1978). Rogoff (1990) further elaborated on Vygotsky's theory, emphasizing the role of social context in learning.

Secondly, Bandura's social learning theory emphasizes the importance of learning through observation and imitation. This theory supports collaborative and interactive learning methods in STEM education, where children learn by observing peers and participating in social interactions. Children learn STEM concepts and skills by observing others, such as teachers or peers. Interactive digital tools and group activities provide rich opportunities for observational learning (Bandura, 1977). Schunk&Zimmerman (1997) discussed the application of social learning theory in

educational environments, emphasizing the effectiveness of role models and observational learning. Teachers and excellent students can serve as role models to demonstrate problem-solving methods and a positive learning attitude, which helps cultivate children's confidence and interest in STEM learning. Pajares (1996) also emphasized the impact of self-efficacy on students' learning motivation and outcomes, as well as the role model of self-efficacy and observation of learning outcomes.

5.4. Findings in the Literature

The research on online and traditional STEM education for preschool children reveals several common themes: (1)Participation and interaction: both methods indicate that participation and interaction are crucial for effective STEM learning. Practical activities, whether through physical manipulation of materials or interactive digital tools, can significantly improve children's understanding and memory of STEM concepts. (2) Participation of parents and teachers: Effective preschool STEM education requires active participation from parents and teachers. In traditional environments, teachers play a crucial role in guiding and promoting learning, while in online environments, parents often need to support and supervise their children's activities. (3) Learning environment: The learning environment, whether virtual or physical, must be stimulating and conducive to exploration. Hirsch Pasek et al. (2015) and Schweingruber et al. (2014) emphasized the importance of creating a rich, engaging, curious, and experimental learning environment.

5.5. Gaps in the Literature

The literature on online and traditional STEM education for preschoolers has established several key themes, such as the importance of participation through hands-on activities and the role of parents and teachers in facilitating learning. However, significant gaps remain in understanding how these educational approaches are experienced by relevant stakeholders, i.e. educators and students. Much of the available research has taken a quantitative approach, focusing on measurable outcomes such as academic achievement and participation levels, while providing limited insight into the context and day-to-day experience of implementing these approaches in different educational settings.

In addition, there is a lack of research to capture the nuances of educators operating within specific cultural and institutional frameworks, such as those in China's preschool education system. Although many studies have explored the effectiveness of STEM education approaches in Western settings, there is limited understanding of how these approaches fit and are perceived in non-Western settings, where educational traditions and resources can vary significantly.

6. Conclusion

Early childhood education is a critical stage of cognitive development, during which foundational skills in science, technology, engineering, and mathematics (STEM) are established. The literature widely supports the role of experiential learning in cultivating children's curiosity and problem-solving abilities. Traditional teaching methods, especially STEM education, emphasize direct interaction with physical materials and promote cognitive development through active exploration - a principle rooted in constructivist theory. However, with the increasing integration of technology into education, the potential of online learning platforms for preschool children is becoming increasingly intriguing. These platforms provide personalized learning experiences and access to a wide range of digital resources, which can complement or even enhance traditional methods.

Despite these potential advantages, there is still considerable uncertainty regarding the effectiveness of online STEM education for young learners. Preschool children, especially those aged 5-6, are in a critical developmental stage where sensory and social experiences are key to learning. The question of whether digital tools can effectively engage children in STEM learning like traditional hands-on methods remains unresolved. In addition, the differences in access to digital resources, especially in different socio-economic contexts, have raised important concerns about the fair distribution of educational benefits. Given the challenges and gaps in the literature, this study aims to explore and compare the effectiveness of online and traditional STEM education methods for preschool children aged 5-6 in China. This study is guided by two main research questions: (1) In what aspects (if any) do online or traditional teaching methods better attract preschool children to participate in STEM learning? (2) What are the differences between online or traditional STEM teaching methods for children aged 5-6?

To address these issues, a qualitative approach was adopted in the study, gathering insights from experienced preschool teachers who have implemented these two educational methods in the classroom. The goal is to identify the strengths and limitations of online and traditional STEM education, understand the background factors that influence its success, and provide recommendations for optimizing STEM learning for young children. The results of this study contribute to the ongoing debate on how to best integrate digital tools into early education while preserving the hands-on interactive experience that is crucial for young learners.

The results of this study indicate that traditional STEM teaching methods, especially those involving hands-on, experiential learning activities, are more effective in engaging preschool children in STEM learning. Teachers unanimously reported that the physical manipulation of materials and direct interaction with the environment attracted children's attention and promoted a deeper understanding of STEM concepts. This is consistent with constructivist theory, which emphasizes the importance of active exploration in cognitive development, especially in early childhood. Research has found that preschool children respond more positively to activities that allow them to experiment, construct, and observe tangible outcomes, as these experiences provide immediate feedback and reinforce learning through sensory engagement.

The results of this study provide a subtle perspective on the effectiveness of online and traditional STEM teaching methods for preschool children in China, emphasizing the necessity of adopting a balanced and context sensitive approach to early childhood education. The results emphasized the sustained relevance of traditional hands-on teaching methods in promoting young children's participation and deeper understanding of STEM concepts, particularly through experiential and social learning. These methods resonate with basic education theories and reinforce the importance of physical interaction and collaboration in early cognitive development. At the same time, the study

emphasizes the growing role of digital platforms in providing personalized learning experiences that cater to the personalized needs of preschool children. However, the effectiveness of these platforms is closely related to external factors such as access to technology and parental involvement. This dependency raises important questions about fairness and the digital divide, indicating that while online methods hold promise, their potential may be limited by socioeconomic disparities. Therefore, this study advocates for a blended learning model that leverages the advantages of traditional and digital methods to create a more inclusive and adaptive learning environment for preschool children.

This study demonstrates several significant advantages, particularly in exploring traditional and online STEM teaching methods for preschool children, which is an increasingly important topic in a constantly evolving educational environment. By focusing on preschool children aged 5-6 in China, this study targets a specific and under researched population, providing valuable insights that can inform educational practices and policies in similar contexts. In terms of methodology, qualitative interviews with experienced preschool teachers can delve into the practical challenges and benefits associated with each teaching method, provide rich, context sensitive data, and enhance understanding of STEM education for young children.

Based on the limitations identified in this study, future research should focus on several key areas to further advance our understanding of STEM education for young children, particularly in the context of comparing online and traditional teaching methods. Firstly, future research should aim to include larger and more diverse samples. Expanding the sample size to include a wider range of preschool educators from different regions, socio-economic backgrounds, and school types will help enhance the generalizability of research findings. This will enable researchers to have a more comprehensive understanding of how different educational environments affect the effectiveness of various STEM teaching methods.

Secondly, a hybrid approach combining qualitative insights and quantitative data can provide a more comprehensive understanding of the impact of teaching methods on student engagement and learning outcomes. For example, future research could include classroom observation, standardized assessment of student performance, and even biometric measurements such as eye tracking or engagement monitoring tools to objectively measure children's interaction with online and traditional STEM activities.

Thirdly, longitudinal studies are needed to evaluate the long-term impact of online and traditional STEM education on children's cognitive development and academic achievement. Understanding how these early education experiences affect children's future success in STEM subjects will provide valuable insights for educators and decision-makers. Longitudinal studies can track children for several years to explore whether the benefits of practical learning persist or whether skills acquired through online learning tools become more relevant as children's education progresses.

In addition, future research should consider the role of parental involvement and external support in online learning, as this study emphasizes the importance of these factors in determining the effectiveness of digital education. Research on strategies to increase parental involvement in online STEM education, especially in resource limited environments, can help bridge the digital divide and ensure that all children benefit from digital learning opportunities.

Finally, cross-cultural comparative research will provide valuable insights into how different cultural and educational environments shape the effectiveness of online and traditional STEM education. Exploring how these methods can be implemented in different countries and education systems can help identify the best practices and innovative approaches that can adapt to different environments. By addressing these areas, future research can build upon the results of this study, contribute to the growth of STEM education knowledge in young children, and provide practical solutions to the challenges identified in both online and traditional teaching methods.

References

[1] Attride-Stirling, J. (2001). Thematic networks: An analytic tool for qualitative research. *Qualitative Research, 1*(3), 385-405.

[2] Aladé, F., Lauricella, A. R., Beaudoin-Ryan, L., & Wartella, E. (2016). Measuring with Murray: Touchscreen technology and preschoolers' STEM learning. *Computers in Human Behavior, 62,* 433-441.

[3] Bandura, A. (1977). *Social learning theory*. Englewood Cliffs, NJ: Prentice Hall.

[4] Berger, P. L., & Luckmann, T. (1967). *The social construction of reality: A treatise in the sociology of knowledge*. Anchor Books.

[5] Berg, B. L. (2009). *Qualitative research methods for the social sciences*. Allyn & Bacon.

[6] Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101.

[7] Braun, V., & Clarke, V. (2013). *Successful qualitative research: A practical guide for beginners*. SAGE Publications.

[8] Brenneman, K., Stevenson-Boyd, J., & Frede, E. C. (2009). Math and science in preschool: Policies and practice. *Preschool Policy Brief*. National Institute for Early Education Research (NIEER).

[9] Bryman, A. (2016). *Social research methods* (5th ed.). Oxford University Press.

[10] Campbell, D. T., & Stanley, J. C. (1963). *Experimental and quasi-experimental designs for research*. Rand McNally.

[11] Charmaz, K. (2006). *Constructing grounded theory: A practical guide through qualitative analysis*. Sage Publications.

[12] Christakis, D. A. (2009). The effects of infant media usage: What do we know and what should we learn? *Acta Paediatrica, 98*(1), 8-16.

[13] Creswell, J. W. (2013). *Qualitative inquiry and research design: Choosing among five approaches* (3rd ed.). SAGE Publications.

[14] Creswell, J. W., & Plano Clark, V. L. (2017). *Designing and conducting mixed methods research* (3rd ed.). SAGE Publications.

[15] Creswell, J. W., & Poth, C. N. (2018). *Qualitative inquiry and research design: Choosing among five a

[16] Hirsh-Pasek, K., Zosh, J. M., Golinkoff, R. M., Gray, J. H., Robb, M. B., & Kaufman, J. (2015). Putting education in "educational" apps: Lessons from the science of learning. *Psychological Science in the Public Interest, 16*(1), 3-34.

[17] Neumann, M. M., & Neumann, D. L. (2014). The use of touch-screen tablets at home and preschool to foster emergent literacy. *Journal of Early Childhood Literacy, 17*(2), 203-220.

[18] Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis: Striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods, 16*(1), 1-13.

[19] Paas, F., Renkl, A., & Sweller, J. (2003). Cognitive load theory and instructional design: Recent developments. *Educational Psychologist, 38*(1), 1-4.

[20] Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*(4), 543-578.

[21] Palinkas, L. A., Horwitz, S. M., Green, C. A., Wisdom, J. P., Duan, N., & Hoagwood, K. (2015). Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. *Administration and Policy in Mental Health and Mental Health Services Research, 42*(5), 533-544.

[22] Patton, M. Q. (1999). Enhancing the quality and credibility of qualitative analysis. *Health Services Research, 34*(5 Pt 2), 1189-1208.

[23] Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd ed.). SAGE Publications.

[24] Piaget, J. (1952). *The origins of intelligence in children*. International Universities Press.

[25] Piaget, J., & Cook, M. (1952). The origins of intelligence in children (Vol. 8, No. 5, pp. 18-1952). *New York: International Universities Press*.

[26] Plowman, L., Stevenson, O., McPake, J., Stephen, C., & Adey, C. (2012). Parents, pre-schoolers and learning with technology at home: Some implications for policy. *Journal of Computer Assisted Learning, 28*(6), 499-511.

[27] Rogoff, B. (1990). *Apprenticeship in thinking: Cognitive development in social context*. Oxford University Press.

[28] Rubin, H. J., & Rubin, I. S. (2012). *Qualitative interviewing: The art of hearing data* (3rd ed.). Sage Publications.

[29] Ryan, G. W., & Bernard, H. R. (2003). Techniques to identify themes. *Field Methods, 15*(1), 85-109.

[30] Schunk, D. H., & Zimmerman, B. J. (1997). Social origins of self-regulatory competence. *Educational Psychologist, 32*(4), 195-208.

[31] Schutz, A. (1967). *The phenomenology of the social world*. Northwestern University Press.