



A Comparative Review of Montessori and Chinese Preschools in Early Mathematics Education in China

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Abstract

Early mathematics education plays a pivotal role in children's cognitive development, shaping their thinking capabilities through various educational philosophies and teaching approaches. In the Chinese educational context, the encounter between different educational systems creates new opportunities for enhancing early childhood mathematics education. This study aims to compare the similarities and differences between Montessori and Chinese kindergarten mathematics education across six key dimensions—philosophical foundations, educational objectives, curriculum design, materials utilization, teacher roles, and instructional methods—in order to identify the complementary strengths of both educational models. While both approaches emphasize hands-on, concrete-to-abstract learning progressions, they diverge significantly in their orientations toward individualization versus collectivism, curricular flexibility, and the degree of teacher guidance. An integrated approach based on the complementary strengths of both models is proposed to enhance early childhood mathematics education practice.

Keywords Montessori education · Chinese preschool · Early mathematics · Early childhood education · Comparative review

Abstraite

L'éducation mathématique dans la petite enfance joue un rôle essentiel dans le développement cognitif des enfants en façonnant leurs capacités de pensée à travers diverses philosophies et approches pédagogiques. Dans le contexte éducatif

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chinois, l'interaction entre différents systèmes éducatifs ouvre de nouvelles perspectives pour renforcer l'enseignement des mathématiques dès le plus jeune âge. Cette étude compare les similitudes et les différences entre l'approche Montessori et l'enseignement des mathématiques dans les jardins d'enfants chinois selon six dimensions clés : fondements philosophiques, objectifs éducatifs, conception curriculaire, utilisation du matériel, rôle de l'enseignant et méthodes pédagogiques, afin d'identifier les forces complémentaires de ces deux modèles. Bien que les deux approches privilégient l'apprentissage concret et une progression du concret vers l'abstrait, elles diffèrent sensiblement quant à l'individualisation versus le collectivisme, la flexibilité curriculaire et le degré de guidage de l'enseignant. Une approche intégrée fondée sur ces forces complémentaires est proposée pour améliorer les pratiques d'éducation mathématique dans la petite enfance.

Abstracta

La educación matemática en la primera infancia desempeña un papel fundamental en el desarrollo cognitivo de los niños, al modelar sus capacidades de pensamiento mediante diversas filosofías y enfoques pedagógicos. En el contexto educativo chino, la interacción entre distintos sistemas educativos abre nuevas oportunidades para fortalecer la enseñanza de las matemáticas en edades tempranas. Este estudio compara las similitudes y diferencias entre el enfoque Montessori y la educación matemática en jardines de infancia chinos a partir de seis dimensiones clave: fundamentos filosóficos, objetivos educativos, diseño curricular, uso de materiales, rol docente y métodos de enseñanza, con el propósito de identificar las fortalezas complementarias de ambos modelos. Aunque ambos enfoques enfatizan el aprendizaje práctico y la progresión de lo concreto a lo abstracto, difieren de manera significativa en su orientación hacia la individualización frente al colectivismo, la flexibilidad curricular y el grado de guía del docente. Se propone un enfoque integrado basado en dichas fortalezas complementarias para mejorar la práctica de la educación matemática en la primera infancia.

Introduction

In recent years, China's early childhood education landscape has undergone growing pedagogical diversity, with the Montessori methodology gaining traction as an alternative to conventional Chinese educational practices. According to the Association Montessori Internationale (AMI, 2022), 15,763 Montessori schools were operating globally in 2022, with China hosting 1,100 institutions, ranking second only to the United States. This trend reflects a broader shift among Chinese parents toward child-centered, developmentally appropriate practices, particularly in foundational domains such as early mathematics. Early mathematics education is critical not only for numeracy skills but also for fostering logical thinking, spatial awareness, and problem-solving abilities. Within this context, a comparative analysis of Montessori and Chinese preschool mathematics education is both timely and valuable. This study aims to compare the similarities and differences between Montessori and Chinese kindergarten mathematics education, identify the complementary strengths of both

models, and explore integration strategies to enhance early childhood mathematics education practice.

The Montessori method provides a distinctive theoretical and practical framework for mathematics education, emphasizing hands-on, self-directed learning through the use of structured materials (Namukasa & Aryee, 2021). In contrast, Chinese kindergarten mathematics education has evolved over the past few decades into a system that integrates life-oriented and play-based learning, shaped by national education policies and cultural priorities (Ministry of Education of the People's Republic of China, 2012). Existing research has demonstrated that the Montessori method exerts a positive influence on the development of children's mathematical abilities. Lillard et al. (2017) found that preschool children in Montessori schools outperformed their counterparts in traditional schools on mathematics achievement tests. In the Chinese context, research has also confirmed that the quality of kindergarten mathematics education has improved following the implementation of the *Guidelines for Learning and Development of Children Aged 3–6* (Yan, 2023). These empirical findings provide an experiential foundation for the comparative analysis undertaken in this study.

As Chinese educational reform increasingly promotes the integration of international pedagogical innovations with local educational needs, there is growing interest in evaluating alternative approaches to early childhood mathematics education. This study employs a literature analysis method to compare the framework designs of both educational systems at the theoretical and policy levels, rather than examining practical implementation in specific schools. The photographs included in the appendix serve solely as illustrative examples to visually demonstrate typical learning materials and instructional contexts within both educational models. This study adopts six comparative dimensions, which are explicitly articulated in the official documents of both educational systems, thereby facilitating an equivalent comparison. Furthermore, this analytical framework aligns with the commonly employed dimensions of analysis in existing comparative education research. The contributions of this study are threefold. First, it addresses a gap in the existing literature by providing a systematic, multi-dimensional comparison of Montessori and Chinese early childhood mathematics education. Second, it offers a theoretical reference framework for localized educational innovation within the context of globalization. Third, it provides insights for other countries facing similar challenges in integrating Eastern and Western educational philosophies.

Montessori Mathematics Education

The Montessori educational methodology, pioneered by Italian educator Dr. Maria Montessori in the early twentieth century, has become an influential model in early childhood education (Namukasa & Aryee, 2021). In mathematics education, the Montessori approach introduces concepts through sensorial experiences using specially designed materials. Central to Montessori's philosophy is the belief that children can naturally cultivate mathematical interest and comprehension within a well-prepared, responsive learning environment (Chisnall & Maher, 2007; Loeffler, 2023; Milinković & Bogavac, 2011).

The Montessori Philosophy

Montessori education is grounded in a rich philosophical tradition, developed through Maria Montessori's empirical observations and scientific inquiry into child development. Her educational philosophy encompasses foundational concepts such as the Absorbent Mind (Montessori, 1992), Sensitive Periods (Montessori, 1936), and the Prepared Environment (Montessori, 1912), along with pedagogical principles like Mixed-Age Groupings (ages 3–6), Freedom and Discipline (Montessori, 1917), and Peace Education (Montessori, 1992). These ideas reflect a holistic view of child development that emphasizes natural cognitive growth, experiential learning, and a respect for the child's autonomy. The following sections explore the core philosophical principles that underpin Montessori's approach to early mathematics education.

The Mathematics Mind

In *The Absorbent Mind* (1949), she proposed the concept of the "mathematical mind"—an inherent sensitivity to logic, classification, quantity, and sequence. This disposition, she argued, enables young children to spontaneously engage in behaviors that reveal early mathematical awareness.

The Cognitive Developmental Pathway from Concrete to Abstract

Grounded in sensorial education and closely aligned with Piaget's cognitive developmental theory, Montessori emphasized that mathematics learning should begin with concrete, tactile experiences. To support this, she designed a wide range of manipulatives—including beads, boards, and boxes—that allow children to engage with mathematical concepts physically. This deliberate progression from concrete manipulation to abstract reasoning ensures that children's mathematical understanding is rooted in experiential learning, fostering long-term conceptual clarity.

The Mathematics Sensitive Period

Montessori described sensitive periods as critical developmental windows when children are uniquely receptive to acquiring specific types of knowledge—a "special sensibility which a creature acquires in its infantile state" (Montessori, 1966, p. 38). Among the various sensitive periods she observed, the one related to mathematics occurs between the ages of 4 and 6. During this time, children display heightened interest in numerical order, quantities, and pattern recognition. Montessori emphasized the importance of nurturing these tendencies early; missing this window may impede later mathematical development.

Error Control and Self-Construction

Montessori rejected traditional punishment-and-reward systems in education, advocating instead for children's autonomous discovery and correction of errors. She designed learning materials with built-in error control, allowing children to identify

mistakes without external correction. A prime example is the Stamp Game, which uses color-coded tiles to represent different place values. If a child miscalculates during an arithmetic operation, the misalignment in quantity becomes visibly apparent, prompting natural self-correction. In this way, Montessori's use of self-corrective materials nurtures independence, critical thinking, and a deep sense of ownership over the learning process.

Education for Peace

In her later years, Montessori expanded her educational philosophy to encompass broader goals of social harmony and global responsibility, articulating the concept of peace education (Montessori, 1992). She viewed mathematics not merely as an academic subject but as a symbolic representation of the universe's intrinsic order. Through mathematical exploration, children engage with patterns, relationships, and logical sequences that mirror the coherence of the natural world. These philosophical underpinnings lay the foundation for the specific aims and structure of Montessori's mathematics education.

Aims of Montessori Kindergarten Mathematics Education

Montessori believed that the goal of mathematics education is to cultivate children's innate mathematical tendencies and help them appreciate the logical beauty and inherent order of mathematics through structured, purposeful activities (Montessori, 1961). As such, precision, structured thinking, and an appreciation for order are considered central qualities of the mathematical mind (Nisa et al., 2019).

Montessori also emphasized the importance of independent thinking and self-correction, facilitated by learning materials embedded with control-of-error mechanisms (Denervaud, 2023; Swargiary, 2024). These tools enable children to identify and resolve mistakes on their own, cultivating critical thinking and problem-solving abilities (Akyol et al., 2023). This capacity for autonomous learning extends beyond mathematics and is regarded as an essential trait for lifelong learning. By engaging children's senses, promoting independent exploration, and nurturing logical reasoning, Montessori mathematics education lays a strong foundation for both academic development and cognitive growth (Bahat heg, 2011; Montessori, 1912).

The Montessori Mathematics Curriculum

Rooted in principles of cognitive development and concept formation, the Montessori mathematics curriculum is a systematic framework designed to support children's progressive understanding of mathematical concepts (Akyol et al., 2023; Mutmainna et al., 2024). This curriculum lays a strong foundation for lifelong mathematical thinking (Brožová, 2022).

Montessori organizes the curriculum into five developmental stages:

Stage 1 introduces the 0–10 number system through tactile materials such as counting sticks, sandpaper numbers, and spindle boxes. These tools help children

internalize numerical concepts by engaging sight, touch, and movement (Zhu et al., 2023).

Stage 2 focuses on continuous numbers, helping children understand large numerical values and laying the groundwork for more advanced topics like algebra and geometry (Basargekar & Lillard, 2021).

Stage 3 emphasizes the decimal system and introduces arithmetic operations using concrete materials that scaffold understanding (Chisnall & Maher, 2007).

Stage 4 reinforces the four fundamental operations—addition, subtraction, multiplication, and division—through manipulatives such as the golden bead material.

Stage 5 explores fractions using visual and tactile tools like circular and square fraction insets to develop part-whole understanding (Lillard, 2016).

Together, these five stages reflect a structured, developmentally appropriate pathway that builds from sensorial readiness to abstract mathematical reasoning. By engaging multiple senses and following a logical progression, the Montessori mathematics curriculum fosters conceptual depth and cognitive confidence in young learners (Namukasa & Aryee, 2021).

Montessori Learning Materials

A distinctive feature of Montessori education is its use of specially designed learning materials, particularly in mathematics instruction. These materials help children grasp foundational mathematical concepts—such as numbers, quantities, and shapes—by transforming abstract ideas into concrete, sensory experiences. Through hands-on exploration, children develop a deep understanding of mathematical relationships by engaging their senses of sight, touch, and movement.

To illustrate the scope and function of these tools, the American Montessori Society has outlined a developmental classification of essential mathematics materials (see Table 1).

While these materials provide the physical structure for learning, their full educational potential is unlocked through pedagogy. The materials themselves represent the static dimension of Montessori education. However, it is the teacher's purposeful and responsive guidance that activates them, transforming them into powerful instruments for mathematical exploration and cognitive growth.

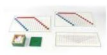
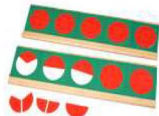
The Montessori Mathematics Pedagogy

Montessori mathematics pedagogy is grounded in the natural laws of child development, emphasizing how children learn best through structured, sensory-rich, and self-directed experiences. Its core characteristics include:

Sensorial Education as Prerequisite

Montessori emphasized that sensorial education forms the foundation of mathematics learning (Montessori, 1949). Through multisensory engagement—tactile, visual, and auditory—children develop a deeper understanding of abstract mathematical concepts. Physical interaction with materials is considered essential for anchoring these concepts in real-world experiences (Montessori, 1949; Politi, 2023).

Table 1 Suggested Montessori Mathematics Materials

Type	Materials					
Recognition of Numbers 0-10						
	Number Rods	Sandpaper Numerals	Spindle Boxes	Numerals and Counters	Memory Game	Short Bead Stair
Continuous Numbers within 100						
	Teen Boards I	Beads I	Tens Boards II	Beads II	Hundred Board	Golden Bead Chain of 100
Decimal System (1-9000)						
	Golden Beads (One Tray)	Golden Beads (Nine Tray)	Number Cards of 1-9000	Bank Game	Short Bead Chains	Long Bead Chains
						
	Addition Snake Game	Subtraction snake game	Addition Strip Board and Tables	Subtraction Strip Board and Tables	Multiplication Board and Tables	Unit Division Board and Tables
Decimal Operations						
	Addition Working Charts	Subtraction Working Charts	Multiplication Working Charts	Division Working Charts	Bead Frame	Stamp Game
Fractions						
	Large Fraction Skittles with Stand			Metal Fraction Circles with two Stands		

All photos taken from Taobao

Sequenced Learning from Concrete to Abstract

The curriculum follows a carefully sequenced progression, beginning with concrete manipulatives and gradually introducing abstract symbols and operations. This structure supports the systematic development of mathematical thinking in alignment with children's cognitive stages (Montessori, 1912).

Self-Correction

Montessori materials are designed with intrinsic error-control features, allowing children to identify and correct their own mistakes independently, without relying on the teacher (Lillard, 2016). In Montessori's view, meaningful learning occurs not through error avoidance but through self-reflection and correction (Montessori, 1917).

These pedagogical principles not only shape the child's mathematical journey but also transform the teacher's role into that of a guide and observer, which is explored in the next section.

Teacher Roles

In Montessori mathematics education, teachers are not mere transmitters of information; instead, they act as observers, guides, and designers of the learning environment to support children's cognitive development in mathematics.

Observer

As observers, Montessori educators play a vital role in understanding each child's learning trajectory. Montessori emphasized the importance of scientific observation in identifying developmental needs and recognizing sensitive periods for learning specific concepts, such as quantity and order (Crneckiy, 2022; Montessori, 1997).

Guide

As guides, Montessori teachers present learning materials with clarity and intention. In *The Advanced Montessori Method* (1917), Montessori described demonstrations as needing to be precise, concise, and complete. Through carefully sequenced presentations—such as the three-period lesson involving naming, recognition, and recall—teachers scaffold children's understanding of mathematical relationships (Jackson, 2011; Montessori, 1912).

Environmental Preparer

As preparers of the learning environment, Montessori teachers create an orderly, engaging space that reflects mathematical logic and invites autonomous learning. The prepared environment is foundational to Montessori's vision, providing children with access to developmentally appropriate materials that they may choose and explore independently (Montessori, 1949).

While Montessori pedagogy emphasizes the teacher's indirect and facilitative role, Chinese early mathematics education presents a contrasting approach shaped by distinct cultural and systemic influences.

Chinese Early Mathematics Education

Chinese early mathematics education has undergone substantial transformation, shaped by evolving national policies and pedagogical frameworks. Between 1952 and 1980, kindergarten mathematics was treated as a discrete subject, with policy documents detailing specific learning content for each developmental stage (Dong & Liu, 2021a, 2021b). During this period, mathematics occupied a distinct position in the early childhood curriculum.

In 1981, the *Outline of Kindergarten Education (Trial)* introduced a more results-oriented approach, emphasizing children's acquisition of knowledge, skills, and mathematical interest (Zhang, 2022). This emphasis on computation continued in the 1985 *Guidelines for Kindergarten Education Work (Draft)* (Peng et al., 2010). However, a significant pedagogical shift occurred in 1989 with the *Kindergarten Work Regulations*, which began to de-emphasize rigid disciplinary boundaries and advocated for integrated learning across domains. This trend continued with the 2001 *Guidelines for Kindergarten Education (Trial)*, which reorganized content into five core learning areas based on children's lived experiences.

The most notable reform came with the 2012 *Guidelines for Learning and Development of Children Aged 3–6* (hereafter referred to as the Guidelines), which redefined the goals of early mathematics education. It promoted a child-centered approach that emphasized the developmental nature of mathematical thinking, the role of play, and contextually grounded learning experiences (Han & Liu, 2019; Jiang, 2019).

Collectively, these reforms reflect China's gradual progression from a skills-based, subject-oriented curriculum to a more integrative and developmentally informed model of mathematics education.

Aims of Chinese Early Mathematics Education

The aims of Chinese early mathematics education are primarily guided by two key national policy documents: the *Guidelines for Kindergarten Education (Trial)* (Ministry of Education of the People's Republic of China, 2001) and the Guidelines (Ministry of Education of the People's Republic of China, 2012).

The 2001 *Guidelines for Kindergarten Education (Trial)* incorporated mathematics into the broader scientific domain, framing instruction around children's natural curiosity about numbers, shapes, time, and space. The document encouraged teachers to nurture early numerical concepts through play and real-world applications, enabling children to use simple mathematical methods to solve fundamental problems in daily life (Ministry of Education of the People's Republic of China, 2001, pp. 2–3).

Building on this, the Guidelines (2012) became the foundational framework for nationwide implementation of kindergarten education. It identifies three primary goals for mathematics learning and development in children aged 3–6:

1. Developing an awareness of the usefulness and interest of mathematics in daily life.
2. Understanding numbers, quantities, and their interrelationships.
3. Exploring the relationships between shapes and space.
4. These objectives underscore a shift in Chinese early childhood education toward contextualized, experience-based mathematics learning that aligns with children's developmental stages.

Chinese Kindergarten Curriculum

Chinese kindergarten mathematics curricula can be broadly categorized into three types based on their developmental orientation: administratively led, institution-based, and emergent curricula.

First, administratively led curricula are guided by provincially standardized materials aligned with the Guidelines (2012). Each province and municipality develops its teaching resources (e.g., the Shandong Province Kindergarten Curriculum Guide), which provide systematic content and pacing for instruction (Chen, 2020). Teachers are also expected to adapt these plans to fit the specific needs of their students and institutions (Chen, 2020).

Second, institution-based curricula have emerged as a significant trend, leveraging local cultural resources—such as folk games and traditional architecture—to create regionally distinctive mathematics learning experiences (Li et al., 2024a, 2024b; Wang, 2024). This approach supports culturally responsive teaching while staying aligned with national guidelines.

Third, emergent curricula, grounded in constructivist theory (Vygotsky, 1978), have gained attention for their responsiveness to children's interests and developmental variation. Teachers dynamically adapt instructional content through ongoing observation and documentation (Chen, 2023; Liu, 2021a, 2021b).

These curriculum types operate within the overarching framework of the Guidelines (2012). From a content perspective, the curriculum is structured around age groups—typically referred to as junior (ages 3–4), middle (ages 4–5), and senior (ages 5–6) classes—and focuses on two core domains: number and shape. Additional emphasis is placed on concepts of quantity, space, pattern, and operations, forming six essential experiences in early mathematics education (Li, 2015).

This synthesis of unified national content with flexible, context-sensitive delivery ensures alignment with national educational objectives while supporting localized and innovative pedagogical practices (Yang, 2017).

Instructional Materials in Chinese Preschools

The development and application of mathematics manipulatives have long been a focus of research in early childhood education in China. The use of such teaching aids dates back to the Republican era, when Chinese educators drew inspiration from Europe, the United States, and Japan (Liu, 2011). One of the earliest pioneers, Chen Heqin, developed culturally specific manipulatives—such as counting cards, rolling bead boards, and spinning bead boards—during his curriculum experiments at Nanjing Gulou Kindergarten (Chen, 1991).

Building on these early innovations, contemporary scholars have proposed various frameworks to classify mathematical materials in Chinese preschools. These materials are typically evaluated based on dimensions such as structural design, functional purpose, durability (consumability), and form Table 2.

Today, Chinese kindergartens utilize a diverse range of mathematics materials tailored to meet the developmental needs of young learners. These include tools that align with children's cognitive levels (Sun, 2014), encourage imaginative thinking through low-structure formats (Pu, 2013), and connect mathematical learning to everyday life (Liu, 2021a, 2021b). Such diversity reflects a pragmatic and culturally responsive approach to mathematics education.

Table 2 Classification of Mathematics Materials

Type	Examples	Image
Operational material kits provided by the provincial curriculum (teaching aids and learning tools)	Mathematics learning cards, puzzles, inlay boards, graphic building blocks.	
Low-structure materials	Wooden sticks, cards, cardstock, dice, building blocks, playing cards, bottle caps, snowflake pieces, magnetic tiles.	
Self-made teaching aids	Shape cards, spinners, and ring toss boxes.	
Manufactured toys	Gomoku, Ludo, chess, Logic Dog materials.	

Table 3 summarizes the key categories of mathematics materials currently used in Chinese kindergartens, along with representative examples that demonstrate their educational purpose and design.

Pedagogy

The *Guidelines for Kindergarten Education (Trial)* (2001) and the Guidelines (2012) emphasize that children's mathematical learning should emerge from meaningful engagement with real-life experiences and hands-on activities. These principles are enacted through four core pedagogical strategies: direct manipulation, life-oriented learning, play-based instruction, and home-school collaboration.

Acquiring Mathematics Experience through Direct Manipulation

Rooted in Piagetian developmental theory, this approach acknowledges that young children's thinking is primarily concrete and perceptual (Piaget, 2005). The 2001 *Guidelines for Kindergarten Education (Trial)* emphasize the use of tangible materials and practical activities to help children explore mathematical concepts through touch, observation, and personal experimentation (Guan, 2025; Zhang, 2020).

Life-oriented Learning Approaches

Grounding mathematics in children's everyday experiences helps make abstract concepts more accessible. The Guidelines (2012) advocate for learning that draws from real-life situations—such as shopping, cooking, or playing outdoors—allowing children to observe, compare, and quantify their surroundings (Yang, 2024). For example, ball games offer opportunities to count, estimate, and compare quantities in context.

Play as the Fundamental Activity

Play is a foundational component of early mathematics instruction. The 2001 *Guidelines for Kindergarten Education (Trial)* emphasize that well-designed games should balance enjoyment with learning objectives and follow a logical sequence from simple to complex tasks (Gao et al., 2015; Yang, 2023). Through play, children develop

Table 3 Early Mathematics Materials in Chinese Preschools

Type	Examples	Image
Operational material kits provided by the provincial curriculum (teaching aids and learning tools)	Mathematics learning cards, puzzles, inlay boards, graphic building blocks	
Low-structure materials	Wooden sticks, cards, cardstock, dice, building blocks, playing cards, bottle caps, snowflake pieces, magnetic tiles	
Self-made teaching aids	Shape cards, spinners, and ring toss boxes	
Manufactured toys	Gomoku, Ludo, chess, Logic Dog materials	

All photos taken from Taobao

not only mathematical skills but also problem-solving abilities and social interaction competencies (Zhang, 2022).

Collaborative Development Between the Home and School

Effective mathematics education is strengthened when schools actively involve families. Teachers often suggest at-home activities to demonstrate how informal environments can support numeracy learning. These practices help parents recognize that mathematics is embedded in daily life and empower them to reinforce mathematical concepts beyond the classroom.

These pedagogical approaches are actualized through the multifaceted roles that teachers play in orchestrating and facilitating meaningful mathematics learning experiences for young children.

Teacher Roles

In Chinese early childhood mathematics education, teachers' roles are shaped by national policy frameworks, notably the *Guidelines for Kindergarten Education (Trial)* (2001) and the Guidelines (2012). These documents outline a developmental approach to mathematics learning and define teacher responsibilities in a way that supports young children's cognitive growth.

In the "Mathematics Cognition" section of the Guidelines (2012) (p. 37), teachers are described as supporters, observers, and guides—roles that reflect a shift toward more responsive and child-centered pedagogy.

Supporter

Teachers act as supporters by providing both material and emotional scaffolding to help children engage with mathematical thinking. The Guidelines (2012) emphasize cultivating children's interest in mathematics, and connecting mathematics to everyday life experiences.

Observer

Teachers are also observers, responsible for closely monitoring children's mathematical development through continuous, informal assessment. Observations of behaviors such as counting, sorting, and problem-solving help teachers tailor instruction to individual developmental levels. The Guidelines (2012) provide age-specific developmental benchmarks to guide this process.

Guide

As guides, teachers expand children's thinking through modeling, questioning, and interactive dialogue. They support children in understanding quantity, applying basic operations like addition and subtraction, and recognizing geometric attributes in their surroundings. Through this role, teachers nurture logical reasoning and problem-solving skills.

With guidance from national policy, Chinese early childhood educators are moving from an authoritative, didactic approach to a more dynamic and supportive one.

Discussion

Based on the above comparative analysis reveals that Montessori and Chinese preschool approaches to early mathematics education share fundamental similarities while maintaining distinct differences. Table 4 summarizes the key similarities and differences identified in this study.

The following sections discuss the similarities and differences between the two approaches along each dimension.

Comparison of Philosophical Foundations

In terms of philosophical foundations, the two educational models exhibit fundamental theoretical divergences while also sharing certain core principles.

Similarities: Both frameworks recognize the staged nature of children's cognitive development and emphasize the importance of aligning instruction with developmental readiness. In Montessori education, this is reflected in the concept of *sensitive periods*, particularly between the ages of 4 and 6, which are seen as critical for developing mathematical understanding (Montessori, 1936; Lillard-Polk, 1972). Similarly, Chinese preschool education, as outlined in the Guidelines (2012), organizes learning objectives by developmental stages (junior, middle, and senior classes), demonstrating an age-appropriate and progressive approach to early mathematics learning.

Differences: Montessori education is grounded in the *mathematics mind* theory, which posits that humans possess an innate sensitivity to mathematical thinking and that children's intrinsic developmental potential naturally unfolds in an appropriately prepared environment (Montessori, 1949). In contrast, Chinese preschool education is fundamentally rooted in social constructivist theory, which emphasizes the construction of mathematical knowledge through dynamic interactions between teachers and students, as well as peer collaboration within sociocultural contexts (Vygotsky, 1978). This difference reflects distinct orientations between individualist and collectivist educational traditions.

Comparison of Educational Objectives

In terms of educational objectives, both models focus on the holistic development of children's mathematical abilities, though with different emphases.

Similarities: Both approaches are committed to cultivating children's interest in and understanding of mathematics, emphasizing that mathematical learning should be connected to children's daily lives. Montessori views mathematics as a reflection of the universe's inherent order, encouraging children to observe and appreciate numerical and spatial relationships in their environment (Montessori, 1949). The Guidelines (2012) similarly emphasizes fostering children's awareness of the practicality and enjoyment of mathematics in everyday life.

Table 4 Similarities and Differences between Montessori and Chinese Early Mathematics Education

Dimensions	Montessori Mathematics Education	Chinese Early Mathematics Education	Similarities/Differences
Philosophical Foundation	• Mathematical Mind theory • Individual autonomous construction	• Social constructivism theory • Collective interaction and cooperative learning	Differences: Individualistic vs collectivistic orientation
Educational Objectives	• Cultivate precision, order, and intelligence • Develop independent thinking and self-correction abilities	• Recognize the fun of mathematics • Understanding of numbers, quantities, and quantitative relationships • Perception of shapes and spatial relationships	Similarities: Mathematical thinking
Cognitive Development Perspective	• Mathematics sensitive period at ages 4–6 • Strict concrete-to-abstract sequence	• Learning objectives set by age groups • Progression from concrete operations to abstract thinking	Similarities: Stage-based cognitive development and concrete-to-abstract pathways
Curriculum Design	• Five-stage sequential design • Fixed instructional progression • Spiral progression structure	• Unified content, diverse models • Three models: administrative-led, school-based, emergent	Differences: Standardization vs diversification
Materials	• Specialized materials • Self-correcting features • Standardized and systematic	• Diverse manipulative materials • Life-oriented and localized resources	Similarities: Manipulative materials Differences: Specialized vs. life-oriented
Teacher's Role	• Observer, guide, environment preparer • Primarily indirect instruction	• Supporter, observer, guide • Combination of direct and indirect instruction	Differences: Passive guidance vs active support
Pedagogy	• Three-period lesson • Primarily individualized learning • Independent exploration	• Life-oriented and play-based instruction • Integration of collective and individual activities • Social interaction	Differences: Individualized vs Socialized learning
Learning Environment	• Prepared environment • Mixed-age grouping (3–6 years) • Free choice of work	• Age-based class system • Thematic activity environment	Differences: Autonomy vs structure
Assessment Methods	• Through observational records • Process-based assessment • Individual development portfolios	• Based on the Guidelines objectives • Balance of outcome and process • Integration of group and individual assessment	Similarities: Child development Differences: Flexibility of assessment criteria

Differences: Montessori education places greater emphasis on developing children's independent thinking, precision, and self-correction abilities (Denervaud, 2023; Swargiary, 2024). Chinese preschool education, in contrast, focuses more on children's understanding of numbers, quantitative relationships, and the exploration of shapes and spatial relationships, while also emphasizing the social functionality of

mathematical competence—that is, applying mathematical methods to solve practical problems in daily life.

Comparison of Curriculum

Curricular design represents one of the most pronounced dimensions of difference between the two models.

Similarities: Both pedagogical models follow a developmental pathway that moves from concrete experiences to abstract reasoning. Montessori education emphasizes the use of hands-on, sensorial materials to help children explore quantitative relationships before transitioning to abstract symbols and operations (Montessori, 1966). Chinese preschool education adopts a similar stance by encouraging children to engage in direct manipulation and experiential learning to construct mathematical understanding (Zhang, 2020).

Differences: Montessori mathematics education follows a five-stage developmental sequence, employs the three-period lesson method, and features a highly standardized curricular structure with strong consistency across global implementations (Montessori, 1912). In contrast, Chinese preschool curricula are structured around unified national guidelines yet offer diverse implementation models—including administrative-led curricula, institution-based curricula, and emergent curricula—to accommodate different regional and institutional contexts (Yang, 2017; Chen & Yuan, 2018; Wang, 2024; Zhao, 2023). Furthermore, Chinese curricula place particular emphasis on play as the foundational activity for learning, as well as the close integration of mathematics learning with real-life contexts (Gao et al., 2015; Yang, 2023).

Comparison of Materials Utilization

In terms of materials utilization, both models place significant value on the role of manipulative materials in mathematical learning.

Similarities: Both systems recognize that manipulative materials serve not merely as tools for engagement but as cognitive bridges connecting real-world experiences with abstract mathematical concepts. Whether through Montessori's structured apparatus or China's varied, life-relevant materials, both approaches underscore the importance of concrete learning experiences in early numeracy development.

Differences: Montessori materials are characterized by their high degree of structure and standardization—such as number rods, spindle boxes, and golden bead materials—each with specific methods of use and pedagogical purposes, and featuring built-in error control mechanisms (Lillard, 2016). In contrast, mathematical materials in Chinese kindergartens come from more diverse sources, including both commercially produced and teacher-made materials, with emphasis on integration with local cultural resources and low-structure designs that encourage children's imagination and creative thinking (Pu, 2013).

Comparison of Teacher Roles

The positioning of teacher roles in the two models reflects their different educational philosophies.

Similarities: Both models position teachers as observers and guides, emphasizing that teachers should attend to children's individual developmental needs and adjust instructional strategies accordingly. Montessori emphasizes the importance of scientific observation in identifying developmental needs and sensitive periods (Crnekiy, 2022; Montessori, 1936, 1997). The Guidelines (2012) similarly describes teachers as supporters, observers, and guides.

Differences: In the Montessori model, teachers primarily serve as designers of the learning environment and indirect facilitators, emphasizing minimal intervention in children's autonomous learning (Montessori, 1949). In Chinese preschool education, teachers typically assume more active instructional roles—engaging in guided questioning, scaffolding, and collaborative problem-solving to support collective learning. Chinese policy also emphasizes teachers' proactive role in constructing and organizing the learning environment to support mathematical development.

Comparison of Instructional Methods

Differences in instructional methods are closely related to the philosophical foundations and teacher role orientations of each model.

Similarities: Both models emphasize the foundational role of sensory education and hands-on manipulation in mathematical learning. Montessori argues that through multi-sensory engagement—tactile, visual, and auditory—children can develop deeper understanding of abstract mathematical concepts (Montessori, 1949). Chinese preschool education similarly emphasizes acquiring mathematical experience through direct manipulation, recognizing that young children's thinking is primarily concrete and perceptual (Guan, 2025; Piaget, 2005).

Differences: A core feature of Montessori pedagogy is self-correction—materials are designed so that children can independently identify and correct their errors without relying on teachers (Lillard, 2016). Chinese preschool education, in contrast, emphasizes diversified instructional strategies, including life-oriented learning, play-based pedagogy, and home-school collaboration. The Chinese model particularly values the role of social interaction and collaborative learning in mathematics education, contrasting with Montessori's emphasis on individual autonomous learning.

Synthesis

The comparative analysis across the six dimensions above demonstrates that, despite originating from different cultural and philosophical traditions, Montessori and Chinese early mathematics education share common ground in recognizing the patterns of children's cognitive development, valuing hands-on manipulation and sensory experiences, and emphasizing the connection between mathematics and daily life. These shared principles reflect a child-centered educational philosophy and provide a foundation for cross-cultural educational exchange.

At the same time, the two models exhibit significant differences in individual autonomy versus collective collaboration, curricular standardization versus flexibility, and the degree of teacher proactivity. These differences are not oppositional but complementary, reflecting different understandings of child development and educational goals across cultural contexts.

Toward an Eclectic Model: Synthesizing Montessori and Chinese Approaches to Early Mathematics Education.

The comparative analysis of Montessori and Chinese early mathematics education reveals both shared principles and divergent practices, reflecting their respective Western and Eastern philosophical foundations (see Table 5). Both approaches emphasize the developmental nature of children's cognitive growth, recognize the importance of concrete-to-abstract learning progressions, and advocate for the use of manipulative materials closely tied to children's lived experiences (Ministry of Education of the People's Republic of China, 2012; Montessori, 1949; Yang, 2024). These shared elements provide a foundation for identifying best practices that transcend cultural contexts.

However, each approach also offers unique strengths. Montessori education prioritizes individual autonomy, intrinsic motivation, and self-correction through the use of precisely sequenced materials and minimal adult intervention (Montessori, 1912; Lillard-Polk, 1972). In contrast, Chinese preschool education emphasizes structured curriculum planning, teacher-led guidance, peer collaboration, and the integration of mathematics learning into everyday social and cultural contexts (Gao et al., 2015; Vygotsky, 1978; Zhao, 2023).

These distinctions are not oppositional; they are complementary. Their integration presents an opportunity to design a more holistic, culturally responsive model of early mathematics education—one that draws on the strengths of both systems. It requires the contextual adaptation of pedagogical principles to align with Chinese values, traditions, and policy frameworks (Deng et al., 2016). This includes the incorporation of life-based content, collaborative learning strategies, and teacher-facilitated scaffolding within Montessori's concrete-to-abstract learning pathway.

Conversely, Chinese preschools may benefit from adopting Montessori's emphasis on developmental sensitivity, individualized learning trajectories, and error-controlled materials to foster greater independence and self-regulation among young learners. By maintaining Montessori's systematic sensorial-to-symbolic structure while embedding it within the social, cultural, and institutional realities of Chinese early childhood settings (Yang, 2018). This hybrid approach can better accommodate diverse learner needs while honoring local educational values and practices.

Conclusion

This comparative analysis highlights valuable opportunities for mutual enrichment between Montessori and Chinese early mathematics education. Chinese preschools can benefit from Montessori's systematic, concrete-to-abstract instructional sequence, self-corrective materials, and emphasis on individualized learning trajectories. Conversely, Montessori programs could be strengthened by incorporating

Table 5 Photos of Montessori and Chinese Early Mathematics Education

Montessori Preschools	Dimensions	Chinese Preschools
	Indoor environment	
	Indoor activity	
	Mathematics materials	
	Group educational activity	
	Outdoor game	
	Outdoor materials	

All photos taken by the first author

Chinese practices that emphasize life-oriented mathematical applications and collaborative learning.

This study has the following limitations. First, the focus on theoretical and policy-level comparison means that a gap may exist between framework-level design and actual classroom practice. Second, the implementation of the Montessori method may vary across different countries; this study primarily references the guidance standards of the American Montessori Society, which may not fully represent the diversity of Montessori practice worldwide. Third, the findings of this study are primarily grounded in the policy and cultural context of China, and considerations of localization factors are necessary when generalizing to other cultural contexts.

However, the successful implementation of such cross-cultural adaptations requires three critical conditions: flexible educational policies, robust teacher professional development, and thoughtful cultural adaptation strategies. Ultimately, effective educational reform—regardless of the pedagogical model adopted—must be grounded in a deep understanding of how young children develop mathematical thinking. This calls for the design of flexible, context-sensitive instructional strategies that respond to individual differences and diverse learning needs, thereby ensuring that all children build a strong and enduring foundation in mathematics. Future research may explore how these integrated models perform in classroom practice, particularly in culturally diverse contexts.

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Declarations

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Consent for Publication This article is a comparative review based solely on published literature and publicly available information.

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