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Chinese Mother–Child Interactions in Everyday Math Activities: Engaging Young Children in Mathematics at Home

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Abstract
Despite the well-documented phenomenon that Chinese parents tend to be actively involved in their young children's education, few studies have explored how Chinese parents manifest math involvement and how their practices operate in early math learning at home. This study investigated Chinese mothers' teaching behavior and its relation to child activity by examining mother–child interactions in everyday math activities. Forty-eight 5-year-olds and their mothers were recruited from 4 kindergartens in Northeastern China, and participated in two everyday mathematical tasks. Mother–child teaching interactions were video recorded. The results revealed that Chinese mothers modified their teaching strategies based on the task, and provided high level of learning-oriented support during the teaching interactions. The findings also suggested that contrary to the stereotypical image of Chinese parents as controlling and punitive, Chinese mothers who used more directive strategies were also more likely to use open-ended and positive strategies in math activities. Furthermore, the findings demonstrated that the relationship between maternal teaching and children's activities seem to resemble the white-middle-class pattern, which indicated open-ended and positive teaching strategies might be more important in promoting children's independent engagement in math tasks than directing and focusing strategies.

Keywords Maternal teaching · Mother–child interactions · Early math instruction · Chinese mothers

A number of studies have explored the nature and effectiveness of parental teaching activities with their preschool aged children, and highlighted the role of parent-child interactions in everyday settings in early childhood education; however few of them have examined parental-child teaching interactions in the mathematical domain (e.g., Zhou 2005; Hyde et al. 2006; Pan, Gauvain et al. 2006; Sun and Rao 2011). Of the studies that do exist, the vast majority were conducted in Western cultures. Researchers have shown that Chinese parents differ from their American counterparts in the nature of parenting, particularly with respect to school related activities (Ng et al. 2007; Huntsinger and Jose 2009; Qin et al. 2009; Cheung and Pomerantz 2011). Based on the Chinese ideologies of the parent role and learning, Chinese parents have traditionally been responsibile for teaching their children at home (Chao 2000); and they were shown to be more involved in early math education when compared with their American couterparts (Chen and Uttal 1988; Huntsinger and Jose 2009; Pan et al. 2006). Considering the fact that Chinese children have been found to outperform their American counterparts in mathematics, shortly after or even before they enter elementary school (Stevenson et al. 1993; Huntsinger et al. 1997; Zhou 2005), it is important to examine the role that Chinese parents play in early math education. This may help us to better understand effective parental involvement in the home and provide more insight on how to facilitate children's early math experiences. To address this critical gap, we explored how Chinese mothers instructed their preschool aged children in dyadic everyday math activities, as well as examined the role of maternal teaching in promoting child independent engagement in math tasks.

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Everyday Activities as a Context for Math Learning

Teaching and learning behaviors are embedded in cultural and social contexts, and everyday activities at home provide context for learning culturally relevant behaviors (Moreno 2000; Dunst et al. 2006; Hyde et al. 2006; Tudge et al. 2006). Research has shown that parental involvement in young children's educational activities, such as shared reading and monitoring homework, can have a positive influence on young children's academic outcomes (Jeynes 2012). Therefore, it is important for researchers to observe and study the interactive learning experiences between parents and their young children during everyday activities and their possible impact on children's future school success.

Evidence has shown that children at a young age have opportunities to be involved in a variety of different mathematical activities (Ginsburg 2006; Guberman 1999; Sonnenschein et al. 2012), and that they are able to acquire a number of mathematical skills through everyday experiences (Saxe 1991; Kalchman 2011). For example, the study of South American street vendors indicated that although the street vendor children received little formal mathematical instruction, they were able to think mathematically in their daily life through invented strategies. The street vendors were found to benefit from their informal mathematical knowledge and perform better in ratio usage than children in school.

Parent-Child Teaching Interactions in Social Contexts

Vygotsky's socio-cultural approach (1978) underscores the importance of adults' role in developing higher mental functions, and cultural influences on the teaching and the learning process. Vygotsky's ideas provide a framework to understand parent-child teaching interactions, especially the transition from joint problem-solving to child independent functioning. During joint collaborative problem solving, children learn to define the task, construct knowledge, and manage the situation through active participation in organized activities with the guidance of adults (Rogoff 1990). One major component of parent-child teaching interactions is the transfer of responsibility, which refers to the decreasing of parents' role in managing the task and the increasing of children's independent behavior in performing the task (Rogoff 1990). Parents are supposed to gradually and sensitively relinquish their responsibility, transfer it to the children and withdraw from the task; as a result, the children will be guided to manage the tasks, and eventually take over the regulatory role and behave independently in the learning activities (Rogoff 1990).

Researchers have shown that effective parent-child teaching interactions can positively influence children's cognitive development and school achievement (e.g., Dieterich et al. 2006; Eisenberg et al. 2010; Hayakawa et al. 2013), and some argued that early parental involvement may have a larger impact compared with parental involvement in later schooling (Chao 2000; Rogala 2001). Moreover, previous studies have underscored the importance of parental autonomy support (e.g., conceptual questions) and positive feedback (e.g., praise) in developing children's self-regulation skills and promoting independent performance (Morrison et al. 2003; Gregory and Rimm-Kaufman 2008; Liew et al. 2014). For example, it was found that mothers' use of distancing strategies (e.g., conceptual questions) and competence attributions (e.g., praise) were predictors of children's independent performance in teaching activities (Diaz 1991). Research suggested that mothers provided supportiveness (e.g., praise), and autonomy support during early teaching interactions, and through these repeated dyadic interactions, mother offered valuable opportunities for children to develop their self-control and self-regulation abilities, which would be transferred to later school life and eventually promote their academic success in school (Morrison et al. 2003; Gregory and Rimm-Kaufman 2008; Liew et al. 2014).

Early Mathematical Instruction in Chinese Culture

Cultural ideologies about parental responsibility and learning may influence parental involvement in children's math learning. Chinese parenting is largely rooted in the Confucian ideas of training and "*guan*", which focus on parents' continuous guidance and monitoring of their children (Chao 2000). Consistent with these cultural notions, Chinese parents tend to view themselves as the primary teachers of their young children and are responsible for hands-on instruction. In addition, Confucianism emphasizes that the first step of an individual's development is the acquisition of knowledge (Li 2005). This view continues to be endorsed by Chinese parents in contemporary society (Luo et al. 2013). The pursuit of knowledge is also considered to be a moral virtue in children, as knowledge is gained through effort, perseverance, and repetition. As such, Chinese parents tend to attach importance to their young children's pre-academic skills (e.g., Pearson and Rao 2003), and believe that the amount of time spent on learning is essential for determining academic outcomes (Jose et al. 2000). There has been a recognition that Chinese parents tend to be more involved in their

children's math learning than their American counterparts (Huntsinger and Jose 2009; Wang et al. 2012).

More generally, teaching and learning processes can vary across cultures due to the different social statuses of the instructor and student, as well as the different expectations held regarding teaching and learning behaviors (Hofstede 1986). For example, teachers in collectivist cultures, such as Chinese culture, generally have a higher status, and the teacher-student relationships are more formal and hierarchical relative to individualistic cultures. Teachers are expected to initiate and direct the learning process and students are expected to follow teachers' instruction without question. Thus teaching activities in collectivist cultures are more likely to be teacher-guided. On the whole, Chinese ideologies of parents' role and the nature of learning may lead parents to believe in the importance of a high level of parental involvement, one that lends itself to more structured teaching of their young children (Chao 2000).

Previous research has reflected a tendency for Chinese parents to provide more structure in the teaching and learning process when compared with European American parent counterparts (e.g., Huntsinger and Jose 2009; Qin et al. 2009; Huntsinger et al. 2011). Specifically, Chinese parents were more likely to use systematic teaching and structure their children's learning environment to a greater degree at home, especially in mathematics (Huntsinger et al. 2000; Huntsinger and Jose 2009; Sun and Rao 2011). Chinese mothers have also been found to adopt a high proportion of directive strategies during teaching interactions with their kindergarteners, and emphasize the accuracy and efficacy of problem solving during the learning process (Sun and Rao 2011).

Task Influences

Research has shown that parental instruction is affected by task characteristics. Specifically, the nature and difficulty of a teaching task could largely affect the instruction process. Mothers tended to use more direct and nonverbal strategies during an unfamiliar tasks, and were more likely to pass the responsibility to the children during a familiar task (Gonzalez 1996). It has also been found that mothers provided more verbal instructions and emotional feedback in everyday activities than in school-based activities (Sun and Rao 2011).

Parents tend to adjust their teaching behaviors based on their different interpretations of various tasks (Rogoff 1990). Mothers' beliefs about the goal of the task were linked to their choice of teaching behavior during reading tasks (Meagher et al. 2008). It has also been proposed that cultural factors may influence maternal selection of the teaching techniques in relation to the task demand. Research comparing maternal teaching across tasks in different cultural groups suggested that there might be a complex relationship among cultural factors, task characteristics, parental teaching strategies and children's learning (Kermani and Brenner 2000). Different languages, socialization patterns, and learning styles may lead to the fact that children across cultures need different kinds of teaching for different tasks.

It remains unclear how Chinese parents manifest their involvement and how their practices operate in their children's early math education. To address this gap, the present study examined Chinese mothers' teaching strategies in two everyday math tasks (geometry puzzle and map task) with their kindergarterners. Specifically, two research questions were explored: (1) How do mothers' teaching behaviors vary across tasks? (2) What is the relationship between mothers' use of various teaching strategies and children's independent engagement in the tasks?

Method

Participants

Participants included 48 Chinese mother–child dyads recruited from four kindergartens in Northeastern China. The schools were located in urban middle-class areas. The children's mean age was 64.8 months (range = 58.0–71.0 months). Twenty-six of the children were female. The mother's mean age was 30.4 years (range = 24.0–42.0 years). Additional demographic characteristics are presented in Table 1. Based on the official data from China's National Bureau of Statistics, the middle class in China was defined as households with an annual income between 60,000 to 500,000 yuan (8452 to 70,439 USD). As can be observed, the majority of the sample were married, employed, middle-class mothers, who had a college degree.

Procedures

All teaching interactions were video-recorded at home in an area where instruction might normally occur. Prior to any instruction, mothers were asked to complete a parent survey. After the survey was completed, a "warm-up" task was given to allow participants to get accustomed to the video camera and procedures. The mothers were then asked to teach their children on the two tasks. The order of tasks was determined randomly using a Research Randomizer. A unique number was assigned to each of the tasks (task 1, task 2) and 48 sets of numbers (1/2, 2/1) were generated and assigned to each parent-child dyad to determine the order of the task. Each dyad was given a 5-min break between tasks.

Table 1 Descriptive statistics for demographic variables (N=48)

Variables	Percent (%)	*M*	*SD*
1. Child age	–	64.80 (months)	4.21
2. Mother age		30.42 (years)	5.31
3. Education		–	–
Less than college	24		
College or higher	76		
4. Employment		–	–
Unemployed	10		
Employed	90		
5. Family income		–	–
25,000-50,000 yuan	4		
50,000-75,000 yuan	8		
75,000-100,000 yuan	21		
100,000-125,000 yuan	31		
125,000-150,000 yuan	26		
Above 150,000 yuan	10		
6. Child gender		–	–
Male	46		
Female	54		
7. Marital status		–	–
Married	94		
Single/divorced/widowed	6		
8. Math preparation		–	–
Junior school math	4		
High school math	42		
One year calculus/higher	54		
9. Confidence in math		–	–
Not good at all	10		
Not very good	12		
Fair	36		
Good	30		
Very good	12		
10. Confidence in math teaching		–	–
Not confident at all	8		
Not very confident	16		
Somewhat confident	30		
Confident	36		
Very confident	10		

Tasks

Two mathematical tasks were used in this study: one map game and one geometry puzzle. The tasks were selected based on previous studies on parent-child interaction in mathematics with young Chinese children (Sun and Rao 2011).

Map Game

The mother–child dyads were given a city bus map (see Fig. 1). The bus fare and the distance between the bus stations are indicated on the map. The distance between the adjacent stations on the green line is one kilometer, and the fare is ¥1; the distance between the adjacent stations on the red one is two kilometers, and the fare is ¥3. Mothers were asked to help their children to find out different routes from the black point to the two yellow points and then decide on the most cost-efficient routes by comparing their travel distances and costs. The map game emphasizes the understanding of numbers and calculation.

Geometry Puzzle

The dyads were given a geometry puzzle (28 pieces) and were asked to complete the puzzle according to a given picture (see Fig. 2). This puzzle game emphasizes the knowledge of basic geometry through combining and manipulating shapes, and recognizing space.

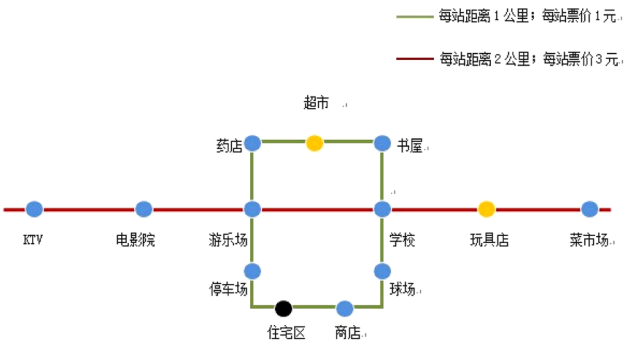

Fig. 1 City map

Fig. 2 Geometry puzzle

Measures

Parent Survey

Mothers were asked to complete questionnaires on demographics including age, marital status, education, math preparation, family income, employment status, and child age.

Maternal Teaching Behaviors

Nine variables were coded on the maternal teaching behaviors as below. Teaching variables were selected from previous literature that examined maternal teaching in mother–child teaching interactions (Diaz et al. 1991; Moreno 2000; Salonen et al. 2007):

1. Perceptual questions: questions to which the answers can be found within the child's perceptual field ("Where should this piece go?"; "What color is this?").
2. Conceptual questions: questions that require a conceptual, mental representation, abstract thought, or plan ("What do you do next?"; "How do you compare the two route options?").
3. Directives: mother directs the child's behavior verbally ("Put the red piece here"; "Let's do this part first").
4. Praise: mother verbally acknowledges that the child has performed in a correct way ("That's right!"; "Good job!") or positive statements about the child's behavior or competence in general ("You are smart!"; "You are so good at this").
5. Labeling: mother labels or describes the task ("This is a pentagon"; "Here is the route from A to B").
6. Correction: mother verbally indicates that the child has performed incorrectly ("This is not right"; "That piece shouldn't go there"), or physically corrects the child's behavior.
7. Contingency: mother uses "bribery" strategies to facilitate the task or manage frustrations ("If you get this done quickly, I will give you the toy you want").
8. Modeling: mother manipulates the task or performs the task for the child to observe.
9. Other verbalizations: non-verbal utterances or statements that cannot fit in any categories above ("well"; "En-huh").

Child Activity

Child's independent engagement in the task was used as an index of mother's transfer of responsibility. This was measured by the amount of time (duration) that the child was actively paying attention to the task, manipulating the task materials in the manner in which they were to be used, or engaged in other task-related behaviors in the final 2 min of the teaching interaction. Non-independent engagement in the task was not included (e.g., attending to the task following mothers' visual cues or directions).

Reliability

Coders were the first author and a Chinese research assistant. The research assistant was first trained by the author. After the assistant had a clear understanding of the coding system, she and the author coded two teaching interactions selected at random. Any discrepancies in coding were discussed by the two coders. When general agreement was reached, 20 mother–child dyads were selected at random and coded independently. Correlation coefficients were computed using the raw frequencies for each variable. For the puzzle task, the coefficients ranged from .69 to .94, median = .85; for the map task, the coefficients ranged from .60 to .92, median =.81. In addition, the Kappa statistic was conducted to determine interrater reliability for each task, which yielded a kappa of .84 for the puzzle task, and a kappa of .79 for the map task. Discrepancies in ratings were discussed and resolved by the two coders.

Results

A 6-min segment of each mother–child interaction was used for data analysis, including the first 2 min, the middle 2 min, and the final 2 min of the teaching interaction. Statistical analysis was conducted to explore: (1) the differences in maternal teaching behaviors across tasks; (2) the relationship between mothers' use of various teaching strategies and children's independent engagement in the final 2 min.

Maternal Teaching Strategies Across Tasks

A principal component analysis (PCA) was conducted to reduce the number of the teaching variables. Items with substantial cross-loadings (larger than .30) were first removed, including labeling, other verbalizations, and correction. After removing the cross-loaded items, for the puzzle task, the first 4 components recorded eigenvalues above 1, explaining a total of 67.51% of the variance (28.32%, 15.41%, 12.60%, and 11.12% respectively), which suggested a 4-factor solution. Oblimin rotation was conducted, and the rotated solution indicated that all 4 factors have a number of substantial loadings. Perceptual questions and directives loaded on factor 1, labeled directing strategies; modeling loaded on factor 2, labeled focusing strategies; conceptual questions and praise loaded on factor 3, labeled open-ended and positive strategies; and contingency loaded on factor 4 (see Table 2). For the map task, the first four components recorded eigenvalues above 1, explaining a total of 68.10%

Table 2 4-factor Solution and Item Loadings for Puzzle Task (N = 48)

Items	Factors			
	Directing	Focusing	Open-ended & positive	Contingency
PQ	.85			
DIR	.73			
MOD		.91		
CQ			.81	
CONTING				.88
PRA			.64	

Factor loadings under (≤) 0.30 are not reflected in the factor matrix

Table 3 4-factor Solution and Item Loadings for Map Task (N = 48)

Items	Factors			
	Directing	Focusing	Open-ended & positive	Contingency
PQ	.83			
DIR	.72			
MOD		.87		
CQ			.82	
PRA			.71	
CONTING				.94

Factor loadings under (≤) 0.30 are not reflected in the factor matrix.

Table 4 Maternal teaching factors by task (N = 48)

	Puzzle		Map		
	M	SD	M	SD	F
Directing	18.39	5.20	15.63	6.08	35.46**
Focusing	7.91	4.07	7.69	5.13	1.20
Open-ended & positive	9.38	6.89	5.04	6.14	40.68**
Contingency	5.02	4.99	7.77	8.17	150.98**

*$p < .05$
**$p < .01$

of the variance (29.25%, 15.24%, 13.28%, and 10.32% respectively), which suggested a 4-factor solution. Oblimin rotation was conducted, and the rotated solution indicated the same pattern of factor loading as the puzzle task (see Table 3).

Descriptive analysis was then conducted to provide a summary of maternal teaching strategies across tasks (see Table 4). There were high level of directing strategies in both tasks. A multivariate analysis of variance (MANOVA) was conducted to examine the differences in maternal teaching factors across tasks (puzzle and map). The analysis revealed a significant difference in mother's overall use of teaching behaviors across two tasks, $F(4, 44) = 60.13$, $p < .01$. The univariate analysis revealed significant differences across tasks in mother's use of directing strategies, $F(1, 47) = 35.46$**, $p < .01$; open-ended and positive strategies, $F(1, 47) = 40.68$**, $p < .01$; and contingency, $F(1, 47) = 150.98$, $p < .01$ (Table 4). An inspection of the mean scores of maternal teaching behaviors indicated that mothers provided more directing, and open-ended and positive strategies in the puzzle task, and more contingency in the map task.

Maternal Teaching Strategies and Child Activity

Next, correlation analysis was conducted between the four maternal teaching strategies and child activity for puzzle and map task respectively (see Table 5 and 6). For the puzzle task, child activity was positively correlated with directing ($r = .34$, $p < .05$), and open-ended and positive strategies ($r = .69$, $p < .01$), and negatively correlated with contingency ($r = -.46$, $p < .01$). That is, maternal use of directing, and open-ended and positive strategies was linked to high level of child independent engagement in the puzzle task, and maternal use of contingency strategies was linked to low level of child independent engagement in the puzzle task. For map task, child activity was positively correlated with directing ($r = .33$, $p < .05$), and open-ended and positive strategies($r = .58$, $p < .01$), and negatively correlated with focusing ($r = -.31$, $p < .05$) and contingency strategies ($r = -.40$, $p < .01$). That is, maternal use of directing,

Table 5 Correlations between teaching factors and child activity for puzzle task (N = 48)

	Directing	Focusing	Open-ended & positive	Contingency	CHILD ACT
Directing	1	.27	.38*	− .10	.34*
Focusing		1	.24	.06	− .04
Open-ended & positive			1	− .31*	.69**
Contingency				1	− .46**
CHILD ACT					1

*$p < .05$
**$p < .01$

Table 6 Correlations between teaching factors and child activity for Map Task (N = 48)

	Directing	Focusing	Open-ended & positive	Contingency	CHILD ACT
Directing	1	.15	.36*	− .19	.33*
Focusing		1	.07	.22	− .31*
Open-ended & positive			1	− .30*	.58**
Contingency				1	− .40**
CHILD ACT					1

*$p < .05$
**$p < .01$

and open-ended and positive strategies was linked to high level of child independent engagement in the map task, and maternal use of focusing and contingency strategies was linked to low level of child independent engagement in the map task. Moreover, open-ended and positive strategies was positively correlated with directing strategies, and negatively correlated with contingency strategies in both tasks. That is, mothers who use more open-ended and positive strategies were also more likely to use more directing strategies, but less likely to use contingency strategies in both tasks.

Moreover, correlations between demographic and control varibles and child activity were examined. Maternal education was found to be positively correlated with child activity ($r = .35$, $p < .05$ for puzzle, and $r = .30$, $p <. 05$ for map), and therefore was controlled in the following analysis predicting child activity. No significant correlations were found between other demographic variables and child activity, indicating that they have little predictive values in determinging the outcome variable of interest.

Hierarchical regression was then conducted to explore the relationship between the four teaching strategies and children's independent engagement, controlling for maternal education. The association between maternal education and child activity became non-significant after the four factors were added in the regression model; next, maternal education was removed and hierarchical regression was run to investigate the relationship between the four teaching strategies and children's independent engagement (see Table 7). For the puzzle task, the analysis revealed that the regression model was significant ($F = 22.14$, $p < .01$) and open-ended and positive strategies were positively associated with child activity ($\beta = .68$, $p < .01$), and contingency strategies were negatively associated with child activity ($\beta = -.23$, $p < .01$). That is, maternal use of open-ended and positive strategies predicted high level of child independent engagement, and maternal use of contingency strategies predicted low level of child independent engagement in the puzzle task. For the map task, the analysis revealed that the regression model was significant ($F = 16.32$, $p < .01$), and that open-ended and positive strategies were positively associated with child activity ($\beta = .62$, $p < .01$), and focusing and contingency strategies were negatively associated with child activity ($\beta = -.19$, $p < .10$; $\beta = -.18$, $p < .10$, respectively). That is, maternal use of open-ended and positive strategies predicted a high level of child independent engagement in the map task, and maternal use of focusing and contingency strategies predicted low level of child independent engagement in the map task.

Table 7 Hierarchical regression predicting child activity (N = 48)

Variables	Puzzle			Map		
	Model 1			Model 1		
	B	SE B	β	B	SE B	β
Directing	.14	.06	.16	.12	.07	.14
Focusing	− .06	.05	− .07	− .14	.08	− .19†
Open-ended & positive	.78	.11	.68**	.55	.10	.62**
Contingency	− .18	.09	− .23**	− .15	.08	− .18†
ΔR^2	.64	.57				
F	22.14**	16.32**				

†$p < .1$
*$p < .05$
**$p < .01$

Discussion

The primary purpose of this study was to examine how Chinese maternal teaching strategies differ across tasks, and the role of different maternal teaching behaviors in promoting children's independent engagement in everyday math tasks. The findings demonstrated that maternal teaching strategies were influenced by task type, and that Chinese mothers provided a high level of learning support in the teaching interactions. Moreover, the results revealed that maternal use of open-ended and positive strategies and contingency strategies were important predictors of child independent engagement in the tasks.

First, the results indicated that overall, Chinese mothers provided a high level of learning-oriented support during the teaching interactions. This is consistent with previous findings that indicate Chinese mothers tend to provide more structured instruction during math interactions with their young children (e.g., Huntsinger and Jose 2009; Sun and Rao 2011). This pattern of results is in keeping with the Confucian ideology that emphasizes the centrality of acquiring knowledge (Li 2005). Chinese mothers emphasize the importance of accuracy in problem solving, leading them to more closely monitor and direct their children during the learning process.

Interestingly, it appeared that Chinese mothers who provided more learning-focused support, also put more effort in engaging the children in the activities. The mothers who used more directing strategies (perceptual questions and directives) were also more likely to use open-ended and positive strategies (conceptual questions and praise) in both tasks. Despite the long-held belief that Chinese parents generally tend to be both controlling and punitive (e.g., Luo et al. 2013), the results here suggests that learning-oriented behaviors, and open-ended and positive strategies are not incompatible. Although this was not anticipated, it is not surprising, as it is consistent with the theory that learning best occurs in an environment where children feel interested and involved (Arnold and Doctoroff 2003). This is in line with previous research in Western cultures which found that mothers who tended to emphasize learning were also more likely to believe that learning should be fun, and that teaching approaches should integrate task learning and child engagement (Arnold and Doctoroff 2003; Meagher et al. 2008).

The results also revealed that Chinese mothers altered their teaching behaviors based on the task. Specifically, mothers spent longer time, showed higher levels of activity, provided more verbal utterances, and used more open-ended and positive teaching strategies in the puzzle task. This finding is consistent with previous research that Chinese mothers tend to encourage more experimentation and provide more positive feedback during the puzzle task as compared to other math tasks (Sun and Rao 2011). This suggests that mothers may adjust their teaching strategies based on their understanding of effective help in different tasks. Parents who tend to believe that a specific task is designed for learning were more likely to show learning-focused behavior (Meagher et al. 2008). The puzzle task, as compared with the map task, may be perceived as a more playful or entertaining activity that requires manual manipulation, which could naturally induce more experimentation and emotional interaction between the mother and the child. In contrast, the map task involves more formal math knowledge (e.g., addition), and the cultural emphasis on acquisition of knowledge may lead Chinese mothers to view it as a serious academic task rather than an interactive activity. As such, in the map task, mothers might feel more responsible for teaching the children how to "do it right", rather than encourage children's exploration and experimentation compared with a more playful task that empasizes hands-on manipulation.

Moreover, the map task is more abstract and complex than the puzzle task, which may affect mothers' use of teaching strategies. This is in line with previous research which found that as task complexity increased, parents were inclined to apply more controlling and nonverbal teaching strategies (Kermani and Janes 1999). Teaching a more complex math task in a collaborative way may require more professional teaching skills and experience. It was found that in complex math tasks, preschool teachers were more likely to provide teaching in a more collaborative manner than mothers, which might suggest that professional training of math teaching is very important for optimal teaching in complex tasks (Sun and Rao 2011). In a less complex activity, mothers may feel more comfortable and less stressed, and it's easier for them to detect their children's competence level, and provide more verbal teaching. When teaching a more complex math task, mothers who lack professional training in early math teaching may not have sufficient knowledge to provide effective instruction in a collaborative way. As such, they may tend to use more controlling strategies, such as correction and contingency, to ensure the success of the task.

Futhermore, the PCA revealed very similar structures of the teaching behaviors for both the puzzle and map tasks (i.e., directing, focusing, open-ended and positive, and bribery strategies) . Besides, when examining the relationship between maternal teaching and children's independent engagement, the four teaching categories also yielded very similar patterns of association to child engagement across tasks. The relatively few differences of the structure pattern and its relation to child activity may be the results of the similar nature of the two tasks. As the tasks used in the study were designed and planned by researchers to solicit certain behaviors, they may be similar in nature compared

with the activities that mothers would typically do with their children in everyday life. The similarity in tasks may have led to the relatively stable patterns in maternal teaching behaviors.

It is also possible that the structure patterns of maternal teaching strategies are universal and stable across different types of tasks. The 4-factor structure revealed in this study has much in common with the dimensions of maternal teaching behavior identified in previous study conducted in western context (Diaz 1991), which may suggest that there might be a stable structure pattern of maternal teaching in early mother–child teaching interactions. It is likely that different dimensions serve particular functions in teaching interactions. For example, directing strategies (directives, perceptual questions) serve the purpose of directing child's performance, focusing strategies (modeling, description) help keep the child on task, and distancing and competence attribution strategies (conceptual questions, praise) help promote child's autonomy and self-regulation skills. Those functional differences may remain stable across different tasks, which may lead to the relatively stable structure patterns of maternal teaching.

Moreover, the analysis suggested that open-ended and positive verbal teaching patterns might be more effective in promoting children's independent engagement than directive and focusing strategies regardless of task. This pattern of results is consistent with previous literature which generally indicated that children tended to benefit from parents' teaching strategies that provided more positive feedback and autonomy support (Morrison et al. 2003; Supplee et al. 2004; Hoff and Tian 2005; Gregory and Rimm-Kaufman 2008; Zhang et al. 2008). The findings here suggest that positive feedback and open-end teaching strategies seem to be crucial in promoting children's autonomy and takeover of responsibility in problem solving. Open-ended strategies such as conceptual questions require children to form mental representation and conceptual thoughts of the task, which may elicit children's thoughts of goals and plans, and therefore may facilitate children's self-regulation skills and independent performance. Affective strategies such as praise may help build a motivational and positive atmosphere in mother–child social interactions; through these positive interactions, mothers may communicate to the children a sense of self-efficacy, which may help facilitate children's self-regulation and takeover behaviors in the teaching interactions.

Additionally, focusing strategies (modeling) was found to be negatively correlated with children's independent engagement in the map task. This finding suggests that it might be important to compare maternal teaching strategies that focus mainly on task completion and those that motivate children's independent performance. Although those strategies may all aim at facilitating the problem-solving process, they may have conceptual and functional distinctions in mother–child teaching interactions.

Finally, mothers' use of "bribery" strategies was negatively associated with children's independent engagement regardless of task. It is not surprising since "bribery" usually occurs when problems arise (e.g., children were not cooperative or distracted), and the mother would promise a a reward or call the child's attention to a future pleasure to prevent the child from withdrawing from the task. Thus, the occurrence of "bribery" strategies are associated with less successful interactions, and therefore was a predictor of low-level child activity. Besides, parents' use of "bribery" could be regarded as a more coercive strategy as compared to information giving behaviors, since it is usually not combined with any developmentally appropriate explanations for why the children should behave in a certain ways for moral reasons (Duncan et al. 2000). The negative association between mothers' use of "bribery" and child activity is also consistent with the overall result pattern of results which suggests that less intrusive and coercive teaching strategies tend to be more effective in promoting children's independent engagement.

There has also been a general debate about the overall appropriateness of using "bribery" strategies with young children. Parents were more often found to use "bribes" to achieve a desired outcome in daily interactions with their chidren, such as facilitating health food choices and getting their young children to do chores (e.g., Li et al. 2018; Tucker et al. 2006). It is argued that using unhealthy food as bribes could reduce children's ability to self-regulate hunger, resulting in overconsumption and obesity (Tucker et al. 2006). Bribery methods have been linked to permissive parenting where parents attempt to control their children or keep their children happy by using gifts or toys (Baumrind 1997; Howenstein et al. 2015). Researchers have argued that making decisions because of bribes may lead to a focus on extrinsic goals and a lack of trust in internal sources (Tucker et al. 2006). The "bribery" strategy is different from positive reinforcement. "Bribes" are used for the purpose of changing a behavior without giving developmentally appropriate explanations of moral reasons (Duncan et al. 2000). Thus, a "bribery" strategy can be viewed as a misuse of external rewards seeking immediate compliance. When mothers use "bribes" to get the children to comply during teaching interactions, children may perceive it as their mother paying them to learn, which could undermine their child's intrinsic motivation for learning and possibly leading to low child activity, regardless of task.

Overall, the pattern revealed in this study is in line with the white-middle-class pattern which argues that more collaborative instruction and positive emotional feedback is more effective in promoting the learning process. It has been argued that optimal scaffolding should follow the

"minimal-sufficiency principle", meaning that in order to maximize children's autonomy and takeover of adult responsibility, only the minimum level of controlling, directives and external rewards should be given in adult-child teaching interactions (Salonen et al. 2007). In contrast, adults' indirect and open-ended teaching strategies would build the bridge between children's independent functioning level and their functioning level with adults' help. Indirect and open-ended teaching strategies could ignite children's takeover of responsibility and "pull" the child towards the new competence level; moreover, in optimal scaffolding, establishing a positive and supportive atmosphere in parent-child social interactions is important. Parents need to give positive emotional response to the children, and by responding in a supportive and positive manner, positive attribution of children's competence will be transmitted to the children, which would enhance their sense of self-efficacy and promote their self-regulation skills (Salonen et al. 2007).

The white-middle-class pattern revealed in this study could possibly be explained by the background characteristics of the sample. Seventy-six percent of the mothers in the sample has a college or higher degree, and the majority of the participants were from middle-class families in urban China. Mothers in a high SES group and with relatively high education level are usually more likely to be exposed to the Western ideas of child-rearing, in which optimal scaffolding usually requires more democratic style of interaction, more collaboration, and positive emotional feedback. As the group of Chinese mothers in this study is very homogenous in terms of formal education level, it is not surprising that the maternal education variable is not a predictor of children's activity when other teaching variables were added. Formal schooling can be a powerful force that makes mothers from different cultural groups behave more similarly, which may be considered as part of the cultural change towards so called "modernization" (Laosa 1980). The background characteristics of the sample may have an influence on the home learning environment and the effectiveness of different teaching strategies, and that's a likely answer as to why the result patterns resemble the white-middle-class pattern. It is also possible that the maternal teaching patterns are similar to the white-middle-class pattern because of the limitations of the tasks used in this study. Although we used informal math tasks and observed the mother–child dyads in home environment to capture naturalistic teaching, the tasks were still designed by the researchers and different from teaching activities that would naturally occur in their daily life. Therefore, it is possible that the informal math tasks used in this study didn't elicit enough cultural specific behaviors in the dyadic teaching interactions.

Limitations and Future Directions

Some cautions must be exercised when interpreting these findings. First, the participants are from middle-class, urban areas of China. Thus, we are limited in the extent that the findings reflect the teaching patterns of mothers' from rural China or those of lower social economic status. Future studies may consider involving a sample with different SES/low maternal education and explore the teaching patterns and their relationships to child performance. Moreover, it would be interesting to replicate this study in different cultures, for example with European American mothers, to come to a global view of how mothers from distinct cultural backgrounds may behave in math teaching interactions. Second, although the study attempted to capture more naturalistic teaching interactions by using more informal math activities in the home, the interactions were still contrived, thus the extent that they accurately reflect naturally occurring home instruction is unclear. Future studies may consider observing everyday teaching interactions that naturally occur in Chinese families to see if the teaching patterns would be different. Despite these limitations, we believe the findings provide additional insight into the role that parents can play in early math education in Chinese culture, added to our knowledge of how family activities may encourage children's engagement in math learning from a global perspective, and have implications for designing parent education programs promoting effective parental involvement in early math experiences.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethics Approval All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The study was approved by Syracuse University Institutional Review Board (Reference Number 15-078).

Consent to Participate Informed consent was obtained from all individual participants included in the study.

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