

Article

Grandparenting Role on Math Online Learning in Chinese Multigenerational Households

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Abstract: Under the COVID-19 pandemic, online learning has become more frequently used and has carried over cultural characteristics. In China, grandparents exert a great impact on parent–child relationships and on children’s online learning process. This study proposed six models and examined the roles of various Chinese family members (father, mother, grandparents) and their online accompaniment time in promoting preschoolers’ math learning. A total of 3552 participants were recruited to finish online questionnaires about demographics, household adult–child interactions, online company time investment, and math language performance. We found that the relationships between father time investment online and children’s math language performance were mediated by the amount of time that maternal grandparents spent with children on online learning. To contextualize these findings, we discussed the unique Chinese cultural aspects of the grandparent–parent–children relationship during the development of online math language performance in Chinese families.

Keywords: online learning; Chinese multigenerational household; math language performance; maternal grandparents’ mediation



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1. Introduction

Online learning is a term that was first used in 1995 when the web-based system WebCT was developed as the first Learning Management System (LMS), which later became Blackboard. Since MOOC (Massive Open Online Course) was widely used in 2013, online teaching modes have gradually been known. Online learning has included many distinct and overlapping terms such as e-learning, blended learning, online education, and online courses [1]. Online learning could be described as access to learning experiences via the use of technologies and it is a newer version or an improved version of distance learning [2,3]. Institutions of higher education have increasingly embraced online education, and the number of students enrolled in distance programs is rapidly rising in colleges and universities throughout the United States [4]. For example, as of fall 2012, of 20.6 million higher education students, 6.7 million (32.5%) were enrolled in online courses in the United States, representing a staggering one-third of higher education students enrolled in online courses [5]. All in all, the growth of online learning has become a global trend, or more likely a mainstream, driven by emergence of new technologies, widespread adoption of internet, and intensifying demand for a skilled workforce for a digital economy [1,6].

The stable development of online learning in recent years has also brought changes and opportunities for most people in China. Several advantages of online learning have been highlighted, such as studying from anywhere, at any time; the possibility of saving significant amounts of money; no commuting on crowded buses or local trains; flexibility to choose; and saving time [7]. The sudden outbreak of COVID-19 shook the entire world and the pandemic forced schools to remain closed temporarily. As a result, various schools have discontinued in-person teaching [8]. Online learning has become the major means of education around the world for it could break the spatio-temporal limitations and improve

learning efficiency [9]. This situation accelerated the transfer from traditional learning to online learning in all levels of education including preschool and elementary education. Additionally, online learning can be downloaded and repeated so that students can review the important and difficult points to achieve better understanding [10]. In addition, the educational resources in China are relatively unbalanced. To be more specific, students in some well-developed cities such as Beijing, Shanghai, Guangzhou, etc., could easily accept better teachers, modern teaching methods, and abundant learning materials and the family investments in children's education is much more than that in less-developed cities in Guangxi, Gansu, and Yunan provinces. There also exists a huge gap between rural and urban areas [11]. Online education can overcome the unequal distribution of educational resources caused by geography and other aspects, make educational resources shared, and lower the threshold of learning, further improving the fairness of education [9]. Apart from the convenience and advantages, studies also show that online learning could help children to understand abstract concepts and engage them in collaborative learning, reasoning, and problem-solving activities [12]. It can serve as a useful tool for children's math language learning, which helps children acquire mathematical skills, thus facilitating later academic achievement [13,14]. Children develop their logic of thinking through the use of math language, whose foundation could be associated with mathematical logic, such as counting, and spatial or dimensional thinking, represented by some basic mathematical concepts [15]. As a result, online learning has gained increasing attention among Chinese households.

Meanwhile, the transition from the traditional face-to-face education mode to online learning brings about changes for both students and parents. Children might spend more time facing electronic devices such as computers, iPads, and smartphones, and young preschoolers might need the company of caregivers to realize effective online learning [16]. The parenting role exerts great influence on children's development during online learning, and the effect might vary with its different characteristics in different cultures. For example, in China, grandparents play an important role in child development. Traditionally, a Chinese family includes under one roof a married couple (grandfather and grandmother), their married sons and daughters-in-law, and their grandchildren and unmarried daughters [17]. This inclusion of three generations within one household gives rise to grandparents' caring for grandchildren. Preschoolers, except in kindergarten, learn math language mainly through early parent-child math-involved interactions at home. That is to say, in China, grandparenting roles at home exert significant influences on children's use of math language. From the beginning as a core part of the child's immediate environment, parents influence their children's learning and development by providing a learning environment for young children [16]. Stevens and Borup [18] found that the role of parents' and grandparents' engagement and company will increase when children are engaged in online learning, as the children tend to face problems with self-management, motivation, and understanding of the learning material without the help of the teacher.

1.1. Time Investment Influencing Children's Math Language Usage

Global time spent with children can be related to math language outcomes. First, daily home activities shared by families and children can stimulate children's mathematical language use in daily life [19]. Skwarchuk et al. [20] inquired 132 parent-child dyads about the frequencies of parent-initiated gameplay involving numbers and quantities. The results showed these gameplays were associated with children's abilities to manipulate quantities. LeFevre et al. [15] also reported children's indirect involvement in informal home activities such as gameplay contributed to good numerical achievements. This is especially true in China where grandparents tend to be responsible for home activities such as picking up their grandchildren and grocery shopping, during which many mathematic literacies may be trained [21].

Second, the dosage and intensity of language exposure matter. Scholars have demonstrated early exposure to mathematical concepts at home is important to math performance [22]. For example, twenty-five parents reported the frequency and time spent with

children in a list of numerical activities such as counting objects and identifying large/small ordinal numbers [23]. The results indicated children exposed to home activities with higher frequency and more time may perform better. To conclude, learning achievements in math could be enhanced by the frequent occurrence of encountering activities or instructions related to math.

Previous studies have also shown extensive attention to parents' or caregivers' roles on children's math language learning in Western countries [24]. Nowadays, the ways and influences of online learning transiting and sustaining in various learning environments are key issues during the pandemic. Novianti and Garzia [25] explored the parental engagement in children's online learning during the COVID-19 pandemic and the result shows that parental engagement in supervising the children's study time is 81.7%, the parent role in accompanying children in online learning is 80.4%, supervising children's study time online is 71.8%, recognizing children's learning difficulties is 69%, and providing online learning facilities is 64.8%. It can be concluded that most parents are engaged in children's online learning activities and help children's, especially preschoolers', educational development.

However, the research on parenting roles in children's online math language learning has not been explored in Chinese culture, and little is known about Chinese preschoolers' math language use in daily life and the relative association of parenting with math language use. Given the fact that Chinese grandparents exert a great impact on both their children and grandchildren, combined with online learning, the role of grandparents in guiding preschoolers' math language use needs to be examined systematically.

1.2. Grandparent Online Accompaniment Impacts on Children's Education

The implementation of online learning for the early childhood education level and kindergarten cannot be carried out independently by children without the assistance of caregivers, most commonly parents. Early childhood requires the direct involvement of caregivers as companions and guides to participate in a series of online learning. They are expected to be able to guide children to learn from home and replace the role of teachers at school. Starting from providing learning facilities in the form of internet-based digital media, learning management at home must be managed by caregivers. Therefore, the guidance and online accompaniment time investment of caregivers in achieving online learning goals and facilitating children's education are of great significance [26].

There is evidence that some of these traditional familial patterns have been preserved in modern China [17]. First, due to the impact of China's "One-Child Policy" from 1979, most parents born in urban areas after 1980 were the only children of their own families, which formed the "4-2-1 family" pattern, i.e., four grandparents, two parents, and one child [27]. Second, with the increasing rate of female employment in China, parents do not have enough time and energy for child care. As a result, the three-generation family with parent-grandparent co-parenting of children is a prevalent phenomenon in Chinese families, especially at the preschool stage [28]. Researchers have found that children who live in multigeneration households have better emotional and behavioral development than children living in single-parent households [29]. However, other studies showed that children who live in multigeneration households have poor academic and physical performance [30], because grandparents, whose educational level apparently could be lower than that of the parents, have a lower expectation of their grandchildren's education [31,32]. These discrepancies indicate that the associations between grandparents' time investment and child learning in China are not yet fully explored.

The modern complex activities make a livelihood become a competition between endless wants and limited means. These situations force many biological parents to often exchange their parenting roles for economic gains and since the grandparents are often old and stay at home to take care of their grandchildren, it is very important to look into their contribution to their grandchildren's totality development [33]. Nyland et al. [34] argued that grandparents might play a significant role in terms of home education of the young, workforce support for young parents, cultural identity within families, and community capacity building. Chinese

parents tend to use grandparent care both because of necessity and because the care of young children has traditionally been a right and an expectation of grandparents. A recent survey in Shanghai found that more than 50 percent of children under three years were raised by grandparents [35]. There are some benefits to the grandparental role in children's education. First, some studies argue that grandparents have plenty of time to accompany their grandchildren during online learning. Most parents are under great economic pressure, so they do not have enough time with their children. Second, grandparents are more patient and tolerant for their grandchildren, which allows grandchildren to create a sense of psychological security and a harmonious communication atmosphere, and as a result, children's special psychological needs could be better satisfied. Third, grandparents are more experienced in child-care than parents and they are willing to communicate with children during their development and education [36,37]. However, we must also admit that there are some limitations to grandparenting, such as grandparents' unreasonable spoiling of grandchildren, relatively lower educational level, and the backwardness of the education concept [37].

Caretaking by grandparents is not limited to China because extended life spans and changes in family arrangements such as increased female employment rates and decreased family sizes have advanced grandparents' roles as caregivers globally such as in the UK and in the United States [38,39]. Denham and Smith [40] introduced two types of grandparental influences. The first type of influence included roles such as playmate, role model, mentor, and historian, whereas the second type of influence included third-party effects such as financial support. However, there was evidence that grandparents' interactions with children were more important than their provision of financial support for their grandchildren's general school attainment, especially in the time of online learning [41]. For preschoolers, grandparents could provide unique resources and input for children. For example, Chinese grandparents regard their grandchild as their emotionally closest relatives. They are motivated, even enthusiastic, to be involved on a full-time basis in raising a grandchild because of the strong tie between parents and their adult children and the cultural priority given to collective family interests, instead of individual interests, in China [42]. They might assist in child care, provide cognitive stimulation, establish an affectionate connection, and pay attention to the children's moral character and manners [34,43].

After the outbreak of COVID-19, the Ministry of Education of China [44] mandated that all schools and universities stop face-to-face teaching and use internet platforms to deliver online learning. Social organizations engaged in designing digital curriculum resources and introducing educational apps and platforms to guide parents and caretakers to support children's learning and play at home. Under such circumstances, many Chinese caregivers (including parents and grandparents) followed the suggestions from teachers and educational authorities to provide online learning to their children during the lockdown [16]. Based on the grandparents' extensive time investment in child caring, we hypothesized that the relationship between parents' online accompaniment time and children's math language use would be at least partially mediated by the grandparents' involvement. Grandparental online accompaniment served as a mediator in the relationship between parental investment and math language use. In other words, the grandparental investment might affect children's math language use. If grandparents put in a larger investment, children would use math language better.

1.3. Parent-Grandparent Relationship in Child Caring and Online Learning

In the West, both maternal and paternal grandparents could be actively involved with their grandchildren [45]. However, the role of maternal and paternal grandparents might differ, particularly in the Chinese context.

Traditionally, kin-keeper theory proposes that women function as the main kin-keepers and take the primary possibility to hold kin members together in most families [46]. It is generally true that, on average, mothers devote more time and effort to child caring and learning than fathers. Moreover, given the close relationship between mothers and maternal grandparents, it is most common for maternal grandparents to help their daughter take

care of their grandchildren when she is occupied with work. Thereby, we hypothesized that the maternal grandparents would play an important role in providing input to the child. Additionally, in order to guarantee their own genetic contribution, fathers are interested in maintaining a patriarchal role in their families [47]. Fathers could increase their time investment in their child's development by involving their own parents in child rearing, particularly for boys. Thereby, we hypothesized that paternal grandparents would play a mediating role in the mother–paternal grandparent co-parenting relationship.

Nowadays, considering the pandemic condition, parents and grandparents both contribute to children's online learning and academic development [25]. As many schools are forced to close and turn to online teaching, children spend more time learning online, and parental and grandparental online accompaniment gains increasing importance. For example, Nurbayani et al. [48] explored the extent of the roles of mothers in accompanying children during online learning and found that the role of mothers is very much needed in assisting children during learning, and children would feel comfortable and have success in learning. Tan et al. [49] examined the parenting role in relation to changes in preschool-aged children's routines and changes in relationship quality between parents and live-in grandparents caused by the pandemic. They found that children's online learning was related to parenting stress and parent–grandparent relationship improvement, indicating that parents and grandparents giving more qualified online time investment may help children's development.

1.4. Current Study

The current study aimed to examine the relationship between online parental time investment and their preschoolers' math language learning and usage by online questionnaire investigation on quantitative language performance (QLP), a measure of children's ability to use math language in general [50], via the mediating role of maternal grandparents. Six specific models were proposed to explore the online accompaniment time that caretakers spend with their children to watch and learn videos or pictures and other resources related to math learning on the internet, which was called online time investment. We further divided this online time investment into fathers' online time investment (DadTime), mothers' online time investment (MumTime), paternal grandfather's online time investment (PGFTime), paternal grandmother's online time investment (PGMTime), maternal grandfather's online time investment (MGFTime), and maternal grandmother online time investment (MGMTime), each as predictors of children's QLP scores.

Four grandparenting variables were independent from each other. Therefore, they were not included in the same model in order to understand the unique contribution of each independent variable to online math language use. In Model 1 (Figure 1a), PGFTime and PGMTime were added as mediating variables between DadTime and children's QLP scores. The mediating relationships were represented by the indirect association of DadTime through PGFTime and PGMTime to children's QLP scores. In Model 2 (Figure 1b), the mediating variables were changed into MGFTime and MGMTime. In Model 3 (Figure 1c), the mediation relations were from MumTime to children's QLP scores through PGFTime and PGMTime. In Model 4 (Figure 1d), the mediation relations were from MumTime to children's QLP scores through MGFTime and MGMTime. Model 5 (Figure 1e) combined the relationships from Model 1 and Model 3, and Model 6 (Figure 1f) combined the relationships from Model 2 and Model 4.

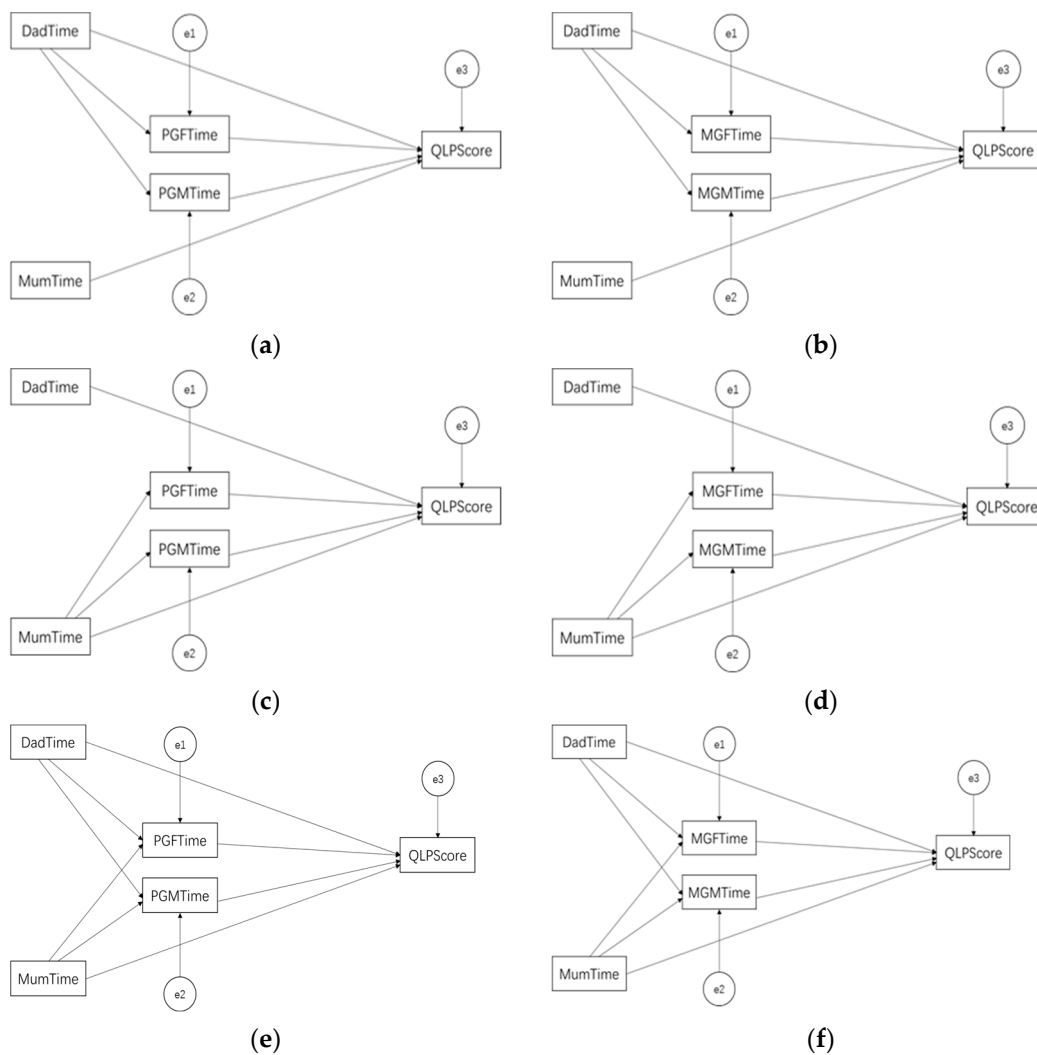


Figure 1. The mediation effects were proposed by (a) PGP mediates DAD (Model 1), (b) MGP mediates DAD (Model 2), (c) PGP mediates MUM (Model 3), (d) MGP mediates MUM (Model 4), (e) PGP mediates Parents (Model 5), (f) MGP mediates Parents (Model 6). Caption: DadTime = father’s online time investment; MumTime = mother’s online time investment; PGFTime = paternal grandfather’s online time investment; PGMTime = paternal grandmother’s online time investment; MGFTIME = maternal grandfather’s online time investment; MGMTIME = maternal grandmother’s online time investment; QLP Score = children’s quantitative language performance score.

2. Materials and Methods

2.1. Participants

A sample of 3552 preschoolers aged 36 months to 60 months ($M = 48$ months) was recruited from grade 1 to 3 among 13 kindergartens in Guilin, Guangxi province, China. They were all from multigenerational families, which means that all grandparents, parents, and grandchildren lived together in the same household. The mean scores for grade 1, 2, and 3 were 8.9, 9.1, and 9.4 (all SDs were above Section 2.2) (see Table 1 for details). We did not find significant differences among the mean scores of the three grade levels. Therefore, we collapsed the three groups for later analyses. To guarantee the reliability and validity of the survey data, the adult participants were specified to be the caregiver who knew the child the best (i.e., the primary caregiver). The mean age of the major parental caregiver was 29.35 years (range from 21 to 38) with an education background at the college level. The mean age of the major grandparental caregiver was 56 years (ranging from 49 to 68) with an education background at secondary middle school. According to the Guilin

Municipal Bureau of Statistics, the average annual family income in Guilin was about USD 3856.3 [51]. Based on the survey data on family socioeconomic status (SES), the average annual family income of our samples ranged from USD 2506.26 to USD 4323.64, supporting that our sample was socioeconomically representative of the local population.

Table 1. Correlation among the Variables.

Study Variables	1	2	3	4	5	6	7
1. DadTime	1.00						
2. MumTime	0.49 **	1.00					
3. PGFTime	0.15 **	0.03	1.00				
4. PGMTime	0.11 **	0.13 **	0.62 **	1.00			
5. MGFTIME	0.29 **	0.17 **	0.02	−0.04 *	1.00		
6. MGMTIME	0.24 **	0.26 **	−0.09 **	−0.15 **	0.60 **	1.00	
7. QLP Score	0.18 **	0.01	0.01	−0.03	0.15 **	0.20 **	1.00
Mean	2.80	4.39	0.95	1.65	0.91	1.39	8.95
SD	2.08	2.57	1.45	2.12	1.40	1.87	2.29
Skewness	1.76	1.35	2.04	1.59	2.08	2.14	0.11
Kurtosis	3.62	1.79	4.64	2.43	5.08	6.65	−0.08

Note. $n = 3552$. DadTime (min) = father's online time investment; MumTime (min) = mother's online time investment; PGFTime (min) = paternal grandfather's online time investment; PGMTime (min) = paternal grandmother's online time investment; MGFTIME (min) = maternal grandfather's online time investment; MGMTIME (min) = maternal grandmother's online time investment; QLP Score = children's quantitative language performance score. * $p < 0.05$; ** $p < 0.01$.

2.2. Procedures and Measures

Schools were contacted and asked to participate in the study. The online questionnaires were distributed by the principals of 13 kindergartens using Mike CRM through social media (i.e., WeChat group). MikeCRM is a customized online data collection form for survey and questionnaire purposes. It has a contact management tool that helps create respondents' contact database for easy correspondence. A sample of 3552 preschoolers and their major caregivers were recruited. There were 1512 students from preschool grade 1 (Mean age = 3.7 years, SD of age = 0.44), 1128 students from grade 2 (Mean age = 4.7 years, SD of age = 0.44), and 912 students from grade 3 (Mean age = 4.7 years, SD of age = 0.11). Prior to completing the online questionnaire, participants were told that they were taking part in a research project on children's math language use and were asked to read an Informed Consent Form and give consent by clicking "Agree". Then, participants completed the online questionnaires in the following order, namely demographic questions, family number survey, and QLP scale. To ensure the fidelity of the subjective measure, we asked parents to promise that they would and have provided the most valuable and real data based on their kids' study situations and educational backgrounds. It took around 20 min for participants to complete all the questions online.

Measures

(1) Demographic Questionnaire. The demographic questionnaire included questions on basic information about the children and the family, i.e., preschoolers' gender, age, family SES, educational level, school district, and the name of their kindergarten.

(2) Family Member Survey. Participants were asked to provide information about the age, income, occupation, educational level, and online time investment of both parents and children's four grandparents in accompanying their children to watch and learn online videos, pictures, and other resources related to math, which allow children to learn math and to use math language expressions. Participants were asked to indicate the major caregiver and the time they spent with the child during the online learning process. The online time investment was inquired by the question: "How much quality time on average (by hours) did you spend with your child in watching and doing online math-related activities (exclusion of sleeping time and meal time)?"

(3) Quantitative Language Performance (QLP) Scale: Children’s QLP was defined as the ability to use math language in general spatial language [50] counting as well as calculation. In the current study, there were 12 dimensions in the QLP scale, namely (1) spatial, (2) shapes, (3) location and direction, (4) orientation and transformation, (5) continuous amount, (6) deictics, (7) spatial features and properties, (8) pattern, (9) processing, (10) comparison, (11) counting, and (12) calculating. The first 10 dimensions were similar to Cannon et al. [50], and we added another two dimensions—counting and calculating—to ensure the QLP addressed comprehensive math language use. See the summary of the content of the 12 dimensions below.

1. Spatial: 26 items about the size of objects, people, and spaces, such as “big”, “long”, and “shallow”.
2. Shapes: 19 items describing the standard or universally recognized form of enclosed two- and three-dimensional objects and spaces, such as “circle”, “oval”, and “triangle”.
3. Location and direction: 65 items describing the relative position of objects, people, and points in space, such as, by, near, and between.
4. Orientation and transformation: 6 items describing the relative orientation or transformation of objects and people in space, such as “turn”, “flip”, and “upside down”.
5. Continuous amount: 41 items describing the amount (including the relative amount) of continuous quantities (including the extent of an object, space, liquid, etc.), such as “whole”, “all”, and “part”.
6. Deictic: 8 items that are place deictic/pro-forms (i.e., these words rely on context to understand their referent), such as “here”, “there”, and “where”.
7. Spatial features and properties: 28 items describing the features and properties of 2D and 3D objects, spaces, people, and the properties of their features, such as “side”, “line”, and “round”.
8. Processing: 24 items describing the dynamic changes of state, such as “from left to right”, “from small to big”, and “from thin to fat”.
9. Comparison: 40 items that indicate the comparative or superlative degree of the adjectives of the quantitative descriptions of the objects such as “bigger”, “smaller”, and “longer”.
10. Pattern: 12 items that indicate a person may be talking about a spatial pattern, such as “next”, “first”, and “last”.
11. Counting: Can your kid count from 1–20? How well shall he/she count? Please rate from 1 to 5 (1 = very poor, 2 = slow, 3 = on average, 4 = relatively good, 5 = very fluently).
12. Calculating: Can your kid do simple calculating (such as $2 + 3$) within 10? How well does he/she calculate (1 = very poor, 2 = slow, 3 = on average, 4 = relatively good, 5 = very fluently)?

The QLP’s reliability and validity are as follows. First, items across the 10 spatial language use dimensions were translated into Chinese by a proficient translator. Then the whole contents across 12 dimensions were evaluated by experts. Cohen’s kappa of 0.8 indicated good rater reliability. Finally, the dimensionality of QLP’s structure was tested. Using the criterion of an eigenvalue greater than 1, exploratory factor analysis showed only one dominant factor was extracted and it explained 58.352 percent of the variance. Each item was rated using a five-point Likert scale (1 = “never use”; 2 = “use little”; 3 = “can use”; 4 = “use a little”; 5 = “use very frequently”). The uni-dimensionality survey showed good reliability, and Cronbach’s alpha value was 0.90. Therefore, QLP is unidimensional and we used the total QLP score for all analyses. To facilitate model estimation, the total QLP total score was divided by 100 [52].

2.3. Data Analysis

Data were examined for outliers, skewness, and kurtosis. Inspection of scatter plots revealed no bivariate outliers. To determine whether multivariate outliers existed, Mahalanobis distance (one method of detecting multivariate outliers) was used to sort all

cases [53]. A probability threshold of $p < 0.001$ for a case being an outlier was used. This procedure did not identify any multivariate outliers. Skewness and kurtosis values were within an acceptable range.

If fewer than 25% of the items were missing in one measure, a person-specific estimate (mean of the non-missing items) was substituted for the missing items. However, if a participant did not respond to 25% or more of the items in any measure, their score on that measure was considered as missing data. We used the multiple imputation method to handle missing data.

A series of fit indices were used to determine a good-fitting, parsimonious model. This current study used fit indices such as the Comparative Fit Index (CFI), Normed Fit Index (NFI), Goodness of Fit Index (GFI), root mean squared error of approximation (RMSEA), standardized root-mean-square residual (SRMR), and the χ^2 statistic. According to Hu and Bentler [54], the comparative fit index (CFI) > 0.95 indicates a good fit and > 0.90 indicates an acceptable fit. The NFI and GFI had similar cutoff values with the CFI. The SRMR < 0.08 indicates a good fit and 0.08 to 0.10 indicates an acceptable fit. Hu and Bentler [55] recommend that the RMSEA should be equal to or smaller than 0.06. Meanwhile, according to Browne and Cudeck [56], RMSEA < 0.05 indicates a good fit; 0.05 to 0.08 indicates an adequate fit, and 0.08 to 0.10 indicates an acceptable fit. In addition, the chi-square test was known to be sensitive to sample size; therefore, a statistically significant chi-square might be acceptable when other fit indices indicated a good model fit [56].

Path analyses were conducted in Amos 17.0 using an Asymptotically Distribution-Free estimation [57] to examine the contribution of the six variables to children's QLP scores. The Sobel test [58] was also used to calculate the p -value of indirect relationships. The Sobel test used a normal approximation which presumed a symmetric distribution. Because of this presumption, the Sobel test was conservative and thus had low power. An alternative method to test indirect effects would be bootstrapping, which was increasingly popular and was regarded as superior to the Sobel test by many researchers. However, bootstrapping might be also criticized for other concerns [59]. For example, Fritz et al. [60] found that the bias-corrected bootstrapping test was too liberal with alpha being around 0.07. Given the large sample size in this study ($n = 3552$), we decided to use the Sobel test for the indirect effects.

3. Results

3.1. Participant Demographic and Family Online Accompany Data

Means, standard deviations, intercorrelations, skewness, and kurtosis are reported in Table 1. The correlations among QLP scores and online DadTime, MGFTime, and MGMTime were statistically significant at the 0.05 level. This indicated that father and maternal grandparents' online accompaniment were highly related to children's math language performance.

3.2. Model-Data Fit

The fit indices for all the models are shown in Table 2. The model fit indices of Models 1, 2, and 3 are in general adequate according to the prevailing criteria. As shown in Table 2, Model 2 with a smaller value of the fit indices (e.g., AIC = 2350, BIC = 2450) could possibly be a better model than Model 1 (e.g., AIC = 3280, BIC = 3170) and Model 3 (e.g., AIC = 2870, BIC = 2750). The fit indices of Model 4, 5, and 6, however, indicate a poor fit. Therefore, we will not discuss Models 4, 5, and 6 further.

Table 2. Model Fit Indices of Six Models.

Model	RMSEA	CFI	NFI	GFI	SRMR	Chi-Square	df
1. DAD + PGparents	0.081	0.949	0.948	0.992	0.0271	48.653 ***	2
2. DAD + Mgpparents	0.078	0.952	0.951	0.992	0.0493	45.416 ***	2
3. MUM + PGparents	0.099	0.924	0.923	0.988	0.0451	71.955 ***	2
4. MUM + Mgpparents	0.137	0.853	0.852	0.976	0.0861	135.744 ***	2
5. Parents + PGParents	0.304	0.643	0.645	0.946	0.1680	329.659 ***	1
6. Parents + MGPParents	0.335	0.562	0.566	0.928	0.1734	399.223 ***	1

Note. $n = 3552$. RMSEA = Root Mean Squared Error of Approximation; CFI = Comparative Fit Index; NFI = Normed Fit Index; GFI = Goodness of Fit Index RMSEA root = square error of approximation; SRMR standardized root mean squared residual. *** $p < 0.001$.

3.3. Path Coefficients

The best-fitting models (Models 1, 2 and 3) supported some main hypotheses of the study. The standardized regression weights (β) are shown in Figures 2–4.

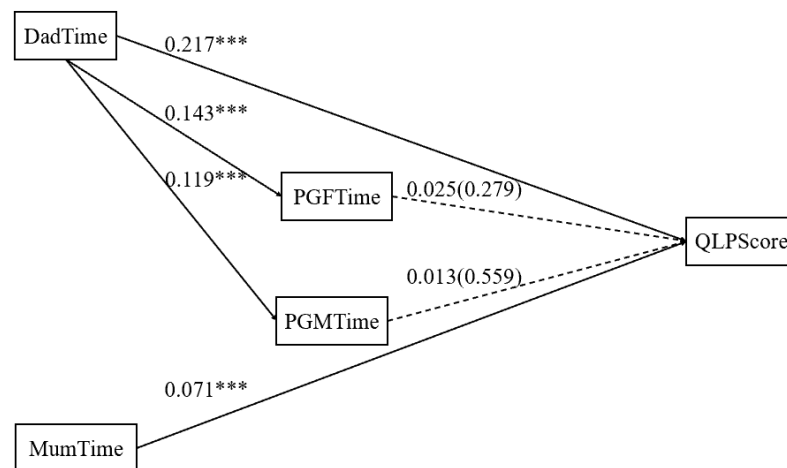


Figure 2. Model 1 Mediation model between dad and paternal grandparents. Caption: $n = 3552$. DadTime = father’s online time investment; MumTime = mother’s online time investment; PGFTime = paternal grandfather’s online time investment; PGMTIME = paternal grandmother’s online time investment; QLP Score = children’s quantitative language performance score. *** $p < 0.001$.

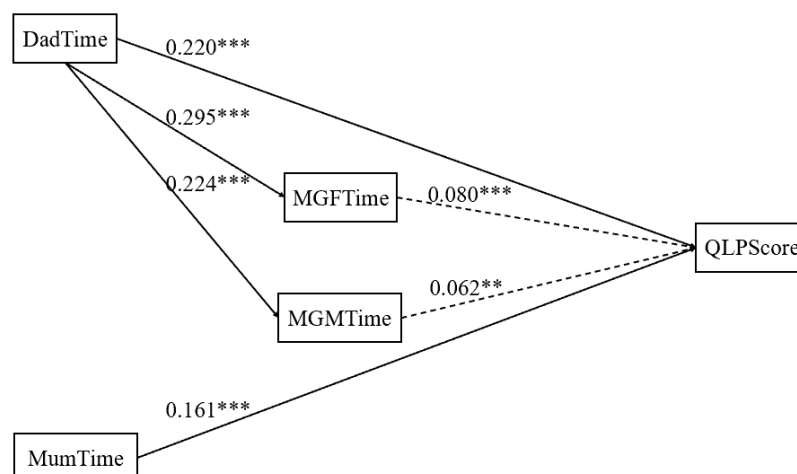


Figure 3. Model 2 Mediation model between dad and maternal grandparents. Caption: $n = 3552$. DadTime = father’s online time investment; MumTime = mother’s online time investment; MGFTIME = maternal grandfather’s online time investment; MGMTIME = maternal online grandmother’s time investment; QLP Score = children’s quantitative language performance score. *** $p < 0.001$, ** $p < 0.05$.

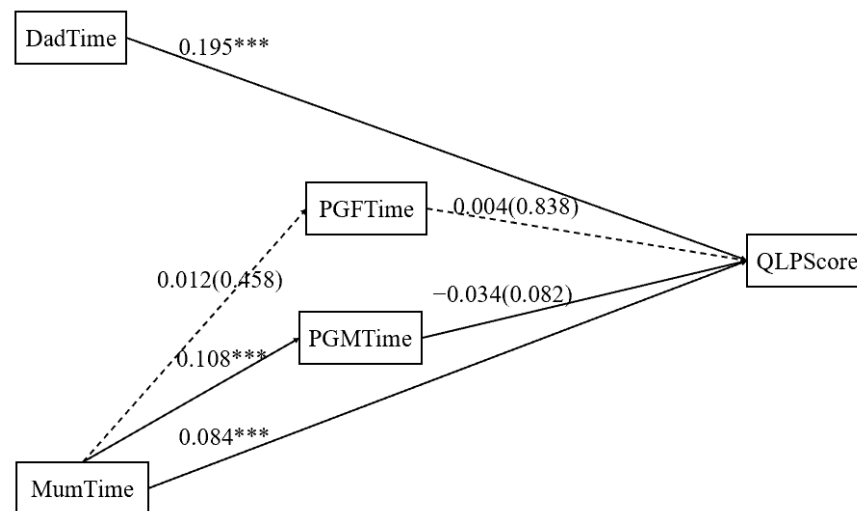


Figure 4. Model 3 Mediation model between mum and paternal grandparents. Caption: $n = 3552$. DadTime = father's online time investment; MumTime = mother's online time investment; MGFTime = maternal online grandfather's time investment; MGMTTime = maternal online grandmother's time investment; QLP Score = children's quantitative language performance score. *** $p < 0.001$.

In Model 1 (as shown in Figure 2), the path coefficient from online DadTime to PGFTime was 0.143; from online DadTime to PGMTime it was 0.119; from online DadTime to children's QLP scores it was 0.217; and from online MumTime to children's QLP scores it was 0.071. These coefficients were all statistically significant at the 0.001 level, indicating that online DadTime and MumTime each have a significant association with children's QLP scores.

In Model 2 (as shown in Figure 3), the path coefficient from online DadTime to MGFTime was 0.295; from online DadTime to MGMTTime it was 0.224; from online DadTime to QLP score it was 0.220, and from online MGFTime to QLP score it was 0.080, and from online MumTime to QLP score it was 0.161. These coefficients were all statistically significant at the 0.001 level, indicating that online DadTime, MumTime, and MGFTime each had a significant association with children's QLP scores. The indirect relationship between online DadTime and QLP score was 0.038, which was statistically significant at the 0.001 level. Therefore, the results of Model 2 indicate that online DadTime had statistically a significant indirect relationship with children's QLP scores through the mediation of online MGFTime and MGMTTime.

In Model 3 (as shown in Figure 4), the path coefficient from online MumTime to PGMTime was 0.108, from online MumTime to QLP score it was 0.084, and from online DadTime to QLP score it was 0.195. These coefficients were all statistically significant at the 0.001 level. This indicates that online DadTime and MumTime are both significantly related to children's QLP scores.

4. Discussion

Adopting the model comparison approach, we collected preschoolers' family survey data based upon their major caregivers, and ran the SEM modeling to test the best-fitting model among six models: (a) PGP mediates DAD (Model 1), (b) MGP mediates DAD (Model 2), (c) PGP mediates MUM (Model 3), (d) MGP mediates MUM (Model 4), (e) PGP mediates Parents (Model 5), (f) MGP mediates Parents (Model 6) (see Figure 1 for details). The uniqueness of each model is summarized below. First, Models 1 and 3 test whether the DadTime or MumTime each have a significant association with child math online learning. Second, Model 2 examines whether the online DadTime indirectly mediates the child's math online learning through the maternal grandparents' accompaniment time with children (Model 2). Third, Model 4 examined whether the online parental accompaniment time

indirectly mediates the child's learning through the paternal grandparents' time. Models 5 and 6 test the combined effects of Models 1 and 3 and Models 2 and 4.

For most students, especially younger children, learning online at home means that parental support is highly required [61]. Parents took on many roles in this setting, including monitoring, motivating, instructing, and organizing. The more online accompaniment time parents spend on their children, the more successful the children's academic development is [62]. It has been determined that young children, regardless of their SES or gender, engage in a considerable amount of mathematical activity during their free play and parents' accompaniment and engagement was found to play a facilitative role in the process of math language learning [63]. Under such context, this study aimed to investigate the relationships between parental and grandparental online accompaniment and time investment in online learning and preschoolers' math language performance in Chinese three-generation families. We conducted online questionnaires on the family background, caregivers' online accompaniment time information, and children's math online learning among 3552 preschoolers and their principal caregivers. Six possible models were hypothesized accordingly. We then conducted the model building and path analyses to examine the mediation effects of grandparents' online accompaniment on children's math online learning performance, as well as the direct parental online time investment with their child's math online learning performance.

All three models show that mothers' online accompaniment time investment with children significantly relates to children's math language usage. Therefore, in our Chinese population, we have replicated earlier findings that mothers have a direct association with their children's math online learning [64]. Additionally, we want to highlight the other three significant findings found in our Chinese multigenerational context. First, there is a direct association between the father's online accompaniment time investment and children's math language use in all these three models. Second, we also found that fathers contribute in an indirect way to their child's math online learning through the mediation of maternal grandparents' association in Model 2. Third, maternal grandparents play a mediating role between fathers and children during the process of math online learning. Good relationships between parents and grandparents also have a positive impact on children [65]. Parents' online time investment with their child has a positive association with grandparents' online accompaniment investment in general. We will then discuss our results taking into account the family pattern features and online learning conditions in China.

4.1. Father Online Accompaniment Time Investment's Relationship with Child's Math Online Learning

Under the lockdown, most parents need to stay at home continuously and work from home online, which means less commute time and more accompaniment time with their children. In the process of children's online learning, parents are expected to be able to guide children to learn from home and replace the role of teachers at school. Parents supported children by (a) organizing and managing their schedules, (b) nurturing relationships and interactions, (c) monitoring and motivating children's engagement, and (d) instructing children when necessary [66]. This study revealed the different roles of parents on time investment in children's online math learning.

Previous studies have shown the important role of mothers' accompaniment time in children's education [48]. Men spend less than half as much time on childcare as women. On average, men spend 6.8 h per week on childcare, compared to 14.0 h for women [67]. As noted earlier, women play the role of kin-keeper with more online accompaniment time investment in the upbringing of children, whereas men are viewed as kin-selectors who are primarily concerned with the economic success of their offspring. From the socioeconomic view and in accordance with Chinese tradition, men tend to specialize in market production and women tend to specialize in home production [67]. With the development of the economy and society, the division that women are responsible for

children's education and housework at home while men are the breadwinners has changed gradually in China [68].

Even though fathers did not spend much time online engaged in childcare, they contribute to children's education more and the father's accompaniment time matters for children's development in early childhood. The results showed that the path coefficient from DadTime to child's math online learning score was positive and statistically significant in Models 1, 2, and 3, which indicates that father online accompaniment time investment in children's online math learning has a direct association with a child's math online learning score. Our findings are in alignment with the view that fathers' online time investment in home learning activities is positively associated with children's literacy and math-related skills [69,70]. Other studies have also shown that children whose fathers were more engaged during shared reading and play sessions had higher cognitive and language development scores, independent of maternal effects [71,72]. Fathers engage in more physical and active play with their children and produce higher-quality child-directed verbal speech than mothers [73], and activities involving number skills are very common to see during play interactions [23].

4.2. Maternal Grandparents Mediate the Relationship between Father Online Time Investment and Child's Math Online Learning

As shown in Model 2, the mediating effect of maternal grandparents' online accompaniment time investment between father online accompaniment and child's math online learning is our most significant finding. In regard to the relationship of father online accompaniment time, maternal grandparents' online accompaniment time, and child's math online learning, the greater the influence of maternal grandparents' online accompaniment on child's math online learning performance is, the greater the influence of father online accompaniment on child's math online learning performance is. Such mediating relationships are in line with the predictions of the kin-keeper theory, which suggests that the good relationship between a mother and her parents allows maternal grandparents to be maximally involved with grandchildren and facilitate children's development overall [65]. Additionally, from the perspective of the Chinese family pattern, the father's respect and tolerance toward maternal grandparents further supports their involvement. Furthermore, when maternal grandparents spend more time with their grandchildren in both life and online learning, the ability of the child's math language use may be enhanced, because they have enough time to accompany and interact with children. This parallels the finding that in the collectivistic and interdependent Chinese family community, grandparents' involvement with their grandchildren during early childhood may positively influence early childhood development and may have life-long advantages [65]. As the "supporting generation", grandparents can provide caring support to establish positive psychological experiences for children, which have benefits and help children to train their mathematical logic and exercise their math language [74]. In general, the finding of maternal grandparental mediation between father online accompaniment time and children's math online learning has significant implications for understanding advances in mathematical understanding due to Chinese patterns of caretaking.

However, grandparents' mediation is not significant in Model 1 and Model 3, which is probably because grandparents' online accompaniment may either facilitate a child's education [75] or depress it [76]. For example, in Model 3, the non-significant path coefficient from paternal grandparents to children's math online learning indicates that paternal grandparents' online involvement may not promote the ability of a child's quantitative language use. On the one hand, it was possible that grandparents' involvement had no significant influence on children's mathematical performance, as they did not talk much with children about mathematics during online learning. On the other hand, a possible explanation might be attributed to parenting stress. The sudden shift to online learning and the challenges it brings are issues of concern because without proper support from parents, these changes may increase the likelihood of parents experiencing parenting stress and

parental burnout, which may in turn negatively impact children [77]. Additionally, when a strict mother puts excessive study pressure on the child, grandparental involvement can buffer the stress because grandparental involvement is associated with lower perceived parenting stress in three-generation families [31,32]. This lower perceived stress from the grandparent may spoil the child and then leads to the decline of math learning.

Furthermore, Models 1, 2, and 3 have shown that parents' online accompaniment time investment with their child has a positive association with grandparents' online time investment in general. One explanation may be that grandparental time investment with grandchildren is positively associated with satisfaction and well-being for grandparents [78,79]. In addition, contemporary society has created the same important roles for both parents in child education. When one of the parents invests more in their child, (s)he would expect the other would invest more. However, the couple would seldom have overlapping leisure time due to work schedules. Therefore, (s)he would involve the grandparents to strengthen the support of their child. Finally, with the popularization and easy operation of smartphones and electronic devices, old people can accompany children in the process of online learning and compensate for parents' online time investment as most grandparents have retired and have enough time and passion to engage in children's online education.

Our findings showed the important role of fathers' and grandparents' time investments in children's online math learning and we speculated the qualified caregivers' time investments might also affect the children's development on the whole, such as language skills, social abilities, and mental health. Milovanska-Farrington [80] explored the impact of grandparents' supervision time input relative to the effect of parents' childcare provision on children's cognitive, social, and behavioral development at an early age. They found that there was complementarity between parental and grandparental involvement in the child-rearing process. Specifically, grandparental care has a stronger effect than parental intervention on the vocabulary skills of the child.

This study has significant practical meanings. First, father online accompaniment time has a close relationship with children's math language performance, indicating that fathers caring for children is beneficial to children, especially preschoolers, and the whole family. As a result, the policing of parental leave could help promote children's academic performance and overall development. Second, the grandparenting role in children's development is of great importance, especially for maternal grandparents. Therefore, maternal grandparents could engage more with their grandchildren.

In conclusion, the current study shows the unique contribution from Dad accompaniment time to kids' math online learning, no matter what the quality is, the quantity works. Moreover, the study reveals the uniqueness of the Maternal Grandparents' mediation role, showing its mediation role in the relationship between the parental contribution and the kids' math online learning. Whether and to what extent the quality works and whether this relationship could extend to the other aspects of learning should be further explored.

4.3. Limitations and Future Research

There are some limitations in the current study. First, we used QLP as an index of math online learning performance, but this measure does not cover all children's math language performance (such as counting, digit recall, addition, and subtraction). Therefore, a more comprehensive and detailed measurement of children's math online learning should be developed.

Second, the current study only measured the online accompaniment time spent by principal caregivers who knew this child best and gave the most realistic and accurate picture of the child's parenting situations. Other family members' engagement in children's education should be added in further study. Additionally, the online time investment was measured by caregivers accompanying their children to watch and learn through activities instead of interactions involving math language because preschoolers' education in China mainly relies on kindergartens and then informal home education. As a result, parental or grandparental interactions involving math language should be paid more attention in

future studies. Furthermore, we asked caregivers to recall their online accompaniment time in the questionnaire, which might be less accurate. Recording or videoing children's online learning activities for the whole day would be more precise and exploring the relationship between online accompaniment time and children's math language usage by a developmental study.

Third, the data were collected from participants from Guilin, Guangxi province, which is located in southern China, and we speculated that in other cities our findings should also stand. With the increasing online learning development and parents' working pressure, grandparents' accompaniment plays an important role in children's learning process. To further elaborate our results and findings that grandparents' accompaniment time online could facilitate children's math online learning among Chinese preschoolers, further studies should recruit participants from other representative cities around different parts of China, such as Beijing in north China and Shanghai in east China.

Finally, many other variables out of the models such as household composition, SES, and parents' educational background may influence children's math performance as well. In future research, we will add such important variables as covariates in the SEM analysis to see if the relationships discovered in this study still hold.

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