

The Relationship between Parental Behavioral Involvement and Mathematics Academic Achievement of Primary School Students: The Chain Mediating Role of Interest in Mathematics Learning and Self-education Expectations

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Abstract: Both domestic and international studies have identified parental behavioral involvement as a significant variable influencing students' academic performance. A review of the literature indicates that the mechanism through which parental behavioral involvement affects students' mathematical academic performance remains incompletely understood. Therefore, using survey data from a sample of 265 students across four primary schools in Y City, Xinjiang, this study employs structural equation modeling (SEM) and Bootstrap techniques to analyze the relationships among parental behavioral involvement, mathematical learning interest, self-educational expectations, and mathematical academic performance. The findings are as follows: Parental behavioral involvement, mathematical learning interest, self-educational expectations, and mathematical academic performance each exhibit significant positive pairwise correlations ($r = 0.18\text{--}0.40$, $p < 0.001$). Both mathematical learning interest and self-educational expectations partially mediate the positive relationship between parental behavioral involvement and mathematical academic performance, with mediating effect values of 0.078 and 0.032, respectively. A chain mediating effect exists between parental behavioral involvement and mathematical academic performance through mathematical learning interest and self-educational expectations, with a mediating effect value of 0.016. The results suggest that parental behavioral involvement among primary school students predicts mathematical academic performance through both direct effects and indirect effects via mathematical learning interest and self-educational expectations.

Keywords: elementary students, parental behavioral involvement, mathematical academic achievement, mathematical learning interest, self-educational expectations.

1. Introduction

Educational activities primarily rely on schools, with family support as a critical factor. Parents' cultural literacy, educational participation, and economic conditions significantly influence children's academic development. Existing research predominantly focuses on multidimensional "parental educational involvement," with particular emphasis on the mechanism of its key dimension—"parental behavioral involvement"—in influencing academic performance. Follow-up studies of classic compensatory programs (e.g., the US Start Program) show parental behavioral involvement more strongly promotes cognitive development than emotional or financial support[1]. However, conclusions diverge: Some confirm its positive effect on math performance[2], while others find home-school communication ineffective or even negative[3]. This study analyzed data from 265 primary students across four schools in Xinjiang's City Y to clarify how parental behavioral involvement impacts math achievement.

1.1 Parental behavioral involvement in the relationship with academic performance in mathematics

Parental behavioral involvement, a key dimension of parental educational involvement, refers to parents' home-based learning management and tutoring for children[4]. It is also termed parental behavioral participation or investment.

A large number of empirical studies show significant correlations between parent-child communication and children's academic performance, particularly in mathematics[5]. A 2010–2019 meta-analysis of parental educational involvement and math achievements found most participation types positively impact performance. For example, TIMSS 2015 data from Singapore and Hong Kong showed parental home learning engagement and educational attitudes significantly improved fourth-grade math scores[6]. Scholars increasingly emphasize measuring distinct dimensions of parental involvement separately. A China-specific behavioral model of parental involvement for primary students has been developed to assess engagement dimensions. Huang et al. (2013) confirmed that "cognitive" and "behavioral" parental involvement directly

enhances math performance in Chinese adolescents[7]. This supports investigating single-dimension involvement. Current trends in China show concentrated parental behavioral involvement (e.g., parent-teacher meetings, learning materials, study monitoring) and limited community/campus engagement, with monitoring being a key behavioral indicator. Based on this, the study hypothesizes (H1): Parental behavioral involvement in primary school positively predicts math academic performance.

1.2 The relationship between interest in learning mathematics and parental behavioral involvement and academic performance in mathematics

Mathematics learning interest, a key non-intellectual factor, influences student learning. It refers to students' eagerness to learn mathematics, comprising four dimensions: understanding mathematical value, positive emotional experiences, accumulated mathematical knowledge, and active learning behaviors[8].

Previous studies often analyzed math learning interest as a factor influencing other variables, focusing on two relationships: ①Parental involvement & interest: A U.S. longitudinal study (primary to high school) showed parental homework supervision, tutoring, and timely praise significantly boost math learning interest[9]. ②Interest & performance: Hong Kong preschooler surveys found a positive correlation between math interest and performance[10], while a Fujian middle school study revealed interested students spend more time on math activities and self-expand knowledge, leading to better grades[11]. These literatures demonstrate pairwise links among parental behavioral involvement, math interest, and performance, but lack exploration of their tripartite mechanism. Drawing on ecosystem theory—family environment influences individual development, and math interest is a key social development component—this study proposes hypothesis H2: Parental behavioral involvement in primary school affects math performance by influencing students' math learning interest.

1.3 The relationship between self-education expectations and parental behavioral involvement and academic performance in mathematics

Self-educational expectations originate from Bandura's "Social Cognitive Theory," representing the concrete manifestation of outcome expectations in students' academic achievements (i.e., individuals' expectations, visions, and goals for their highest attainable educational level). The theory posits an interactive, mutually influential relationship among behavior, individuals, and the environment[12].

Studies identify parental family involvement as a predictor of children's educational expectations. Analyzing CEPS 2014 data, scholars found parental communication and activity management significantly enhance seventh- and ninth-graders' self-educational expectations[13]. Other research treats self-educational expectations as an influencer of math performance: a Spanish study on junior high students showed academic expectations positively correlate with math and science scores[14]. Given parental involvement influences self-educational expectations, which in turn predict academic performance, self-educational expectations may mediate the effect of parental involvement on math achievement. While Chinese scholars have established the "parental involvement-self-educational expectations-academic performance" pathway[15], this mechanism remains unexamined in mathematics. Thus, hypothesis H3 is proposed: Parental behavioral involvement in primary school affects math performance by influencing students' self-educational expectations.

1.4 The relationship between Interest in mathematics learning and expectations of self-education

As mentioned above, both math learning interest and self-educational expectations may mediate the link between parental behavioral involvement and math performance. This study examines both mediating variables and analyzes potential chain effects: whether parental involvement first cultivates math interest, then self-educational expectations, or vice versa. Both pathways are developmentally plausible and underexplored. Previous research highlights interest's predictive role in self-educational expectations[16]. Swedish studies show math interest significantly predicts junior high girls' educational expectations, with longitudinal data supporting this link. Based on this, hypothesis H4 is proposed: Parental behavioral involvement in primary school influences math performance through a chain effect: math learning interest → self-educational expectations.

In conclusion, This study constructs a chain mediation model where parental behavioral involvement influences math learning interest, thereby affecting self-educational expectations and ultimately math performance. The model aims to deepen understanding of how parental involvement impacts math achievement and provide empirical evidence for educational practices. The research hypothesis model is shown in Figure 1.

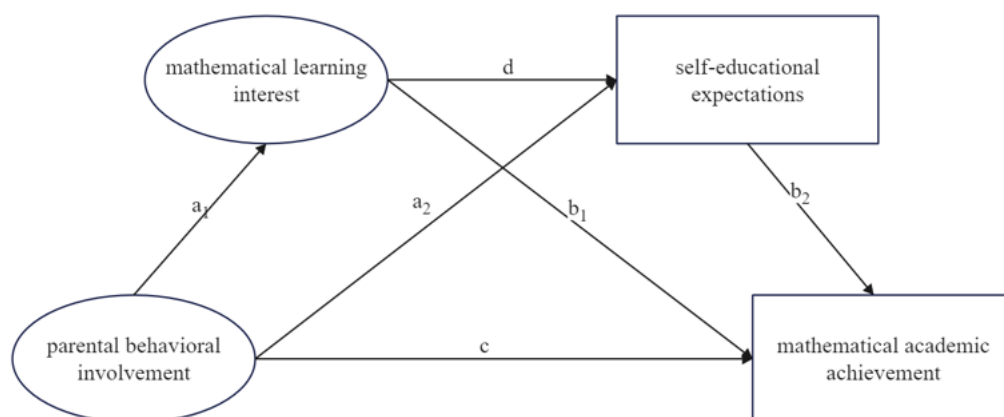


Figure 1. Hypothesis model

2. Methods

2.1 Participants

This study samples City Y in Xinjiang using cluster random sampling: 4 primary schools are randomly selected, with one fourth-grade class per school. A total of 290 questionnaires were administered, yielding 265 valid responses (91.37% validity rate) after excluding incomplete/invalid data. Sample demographics (Table 1) include 133 male students (50.19%) and 132 female students (49.81%).

Table 1. Sample information (N=265)

	Category	Number	Percentage (%)
Gender	Male	133	50.19
	Female	132	49.81
Nation	Ethnic Han	94	35.47
	Minority	171	64.53
Area	City	118	44.53
	Mural	147	55.47

2.2 Measures

2.2.1 Parental behavioral involvement

This study adapted Xia Yuan's (2020) parental education involvement questionnaire, using only the five-item behavioral involvement subscale[17]. Rated on a 5-point Likert scale (higher scores = higher involvement), the subscale showed good internal consistency ($\alpha=0.785$). Confirmatory factor analysis revealed acceptable model fit ($\chi^2=291.42$, $df=74$, $p<0.001$; CFI=0.934, TLI=0.919, RMSEA=0.073, SRMR=0.059), with all indices meeting criteria (CFI/TLI>0.9, RMSEA/SRMR<0.08)[18]. Thus, the scale demonstrated satisfactory reliability and validity.

2.2.2 Mathematical learning interest

The mathematics learning interest questionnaire adapts from TIMSS2019[19], comprising nine items on a 5-point Likert scale ($\alpha=0.896$). Confirmatory factor analysis showed acceptable fit ($\chi^2=141.632$, $df=26$, $p<0.001$; CFI=0.958, TLI=0.942, RMSEA=0.079, SRMR=0.037), indicating good reliability and validity.

2.2.3 Self-educational expectations

Adapted from Zhang et al. (2011)[20], the self-education expectations measure uses a single-item question: "I hope I can go to school". Response options (with numerical codes) are: 1=Primary school, 2=Junior high school, 3=Senior high school (vocational/technical schools included), 4=University (junior college/undergraduate), 5=Postgraduate (master's/doctoral).

2.2.4 Mathematical academic achievement

Mathematics academic performance is measured by students' final exam scores from standardized tests organized by the local education department, with data collected from class math teachers. Exam content aligns with the semester's curriculum, covering topics in numbers and algebra, geometry, and statistics.

The questionnaire survey was tested on a class basis. Before the test is conducted, the purpose of this survey will be informed to the subjects, and the confidentiality of the survey responses will be emphasized. The questionnaire was conducted in the form of a paper questionnaire, and then the data was sorted and screened by a dedicated person. Finally, SPSS26.0 and Mplus 7.4 were used for relevant statistical analysis.

3. Results

To address common method bias, Harman's single-factor test was applied via principal component analysis. Results revealed four factors with eigenvalues >1 , with the first factor accounting for 33.27% of variance (below the 40% threshold) [21]. Thus, common method bias was not a significant issue in this study.

3.1 Correlation analysis

It can be known from the correlation analysis results in Table 2 that parental behavioral involvement has a significant positive correlation with mathematics learning interest, self-education expectations, and mathematics academic performance. Mathematics learning interest has a significant positive correlation with both self-education expectations and mathematics academic performance, and self-education expectations have a significant positive correlation with mathematics academic performance. That is to say, There are significant positive correlations between any two of the variables such as parental behavioral involvement, interest in mathematics learning, expectations for self-education, and academic performance in mathematics. ($r=0.189-0.401$, $p<0.001$).

Table 2. The correlation of each variable (N=265)

Variable	M \pm SD	1	2	3	4
1. Parental behavioral involvement	3.84 \pm 0.79	—			
2. Mathematical learning interest	4.37 \pm 0.78	0.269***	—		
3 Self-educational expectations	4.61 \pm 0.67	0.189***	0.192***	—	
4. Mathematical academic achievement	75.21 \pm 24.61	0.233***	0.401***	0.201***	—

Note: * $p<0.05$, ** $p<0.01$, *** $p<0.001$; the same below.

3.2 Analysis of mediating effect

Based on the relationship between parental behavioral involvement and mathematics academic performance, two mediating variables, namely mathematics learning interest and self-education expectation, were included. The chain mediating effects of mathematics learning interest and self-education expectation between parental behavioral involvement and mathematics academic performance were examined according to the mediating effect analysis process.

Firstly, the direct effect of parental behavioral involvement on students' mathematics academic performance was examined. Model fit indices were: $\chi^2=14.868$, $df=9$, $p<0.001$, CFI=0.973, TLI=0.955, RMSEA=0.050, SRMR=0.041, indicating a good fit. Parental behavioral involvement significantly and positively predicted mathematics performance (standardized path coefficient: $\beta=0.320$, $p<0.001$).

Secondly, path analyses included parental behavioral involvement, math learning interest, self-education expectations, and mathematics performance (Figure 2). The model fit indices ($\chi^2=211.55$, $p<0.001$, $df=112$, CFI=0.932, TLI=0.917, RMSEA=0.059, SRMR=0.055) confirmed acceptable fit.

Finally, a bias-corrected percentile Bootstrap method (N=1000, 95% CI) assessed mediating effects (Table 3). All 95% CIs excluded 0, indicating significant mediation: ①Path c: Parental involvement directly predicted mathematics performance ($\beta=0.194$, $p<0.01$; CI [0.057, 0.326]), explaining 60.62% of the total effect. ②Paths a1-b1: Parental involvement \rightarrow math interest ($\beta=0.341$, $p<0.001$) \rightarrow performance ($\beta=0.229$, $p<0.001$), with a mediating effect of 0.078 (CI [0.039, 0.144]; 24.38% of total effect). ③Paths a2-b2: Parental involvement \rightarrow self-education expectations ($\beta=0.174$, $p<0.01$) \rightarrow performance ($\beta=0.184$, $p<0.001$), with a mediating effect of 0.032 (CI [0.007, 0.076]; 10% of total effect). ④Chain path a1-d-b2: Math interest significantly predicted self-education expectations ($\beta=0.248$, $p<0.01$), with a chain mediating effect of 0.016 (CI [0.005, 0.039]; 5% of total effect).

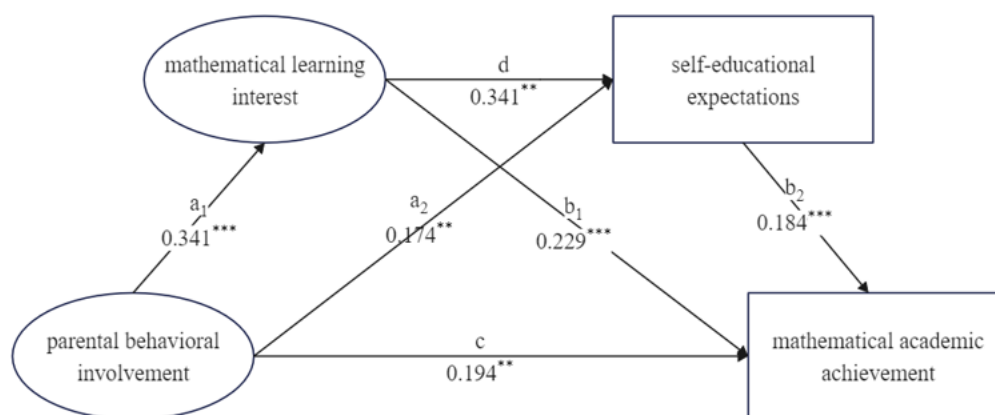


Figure 2. Mediation effect path diagram

Table 3. Mediation Effect Analysis

Paths	Effect size	SE	95%(CI)		Proportion of the total effect
			Lower 2.5%	Upper 2.5%	
Direct effect	0.194	0.068	0.057	0.326	60.62%
Total indirect effect	0.126	0.031	0.075	0.199	39.38%
Involvement-interest-Performance	0.078	0.026	0.039	0.144	24.38%
Involvement-expectation-Performance	0.032	0.017	0.007	0.076	10%
Involvement-interest-expectation. Performance	0.016	0.008	0.005	0.039	5%

(Note: The standardized regression coefficients and their standard errors were calculated byusing Bootstrap sampling with deviation correction for 1000 times)

4. Discussion

4.1 The influence of behavioral involvement on academic performance

This study finds that the direct effect of parental behavior involvement in the mathematics academic performance of primary school students is significant, indicating that parental behavior involvement has a positive impact on students' mathematics performance. This result supports research hypothesis H1 and is consistent with previous domestic research results among sixth-grade students in the Guangzhou area[22]. That is, Students with lower parental investment exhibit poorer academic performance compared to those with higher investment, verifying the direct impact of parental behavioral involvement on primary students' mathematics achievement. This aligns with Brown-Brenner's ecosystem theory, where parents as microsystem members directly influence children's learning through behaviors[3]. Higher parental engagement in study supervision, parent-child activities, communication, and tutoring reflects stronger family emphasis on education, particularly for mathematics—an abstract and logically rigorous subject. Such involvement meets students' psychological needs in math learning, enhances their attitudes, and improves outcomes [23]. Thus, parents should prioritize behavioral participation to foster academic growth.

4.2 Independent mediating effect

This study finds that interest in mathematics learning and expectations of self-education play a partially positive mediating role respectively between parental behavioral involvement and mathematics academic performance. On the one hand, interest in mathematics learning, as an internal and cognitive motivation among mathematics learning motivations, is closely related to an individual's psychological variables[24]. Although existing studies have rarely taken mathematics learning interest alone as a mediating variable to explore the relationship between parental involvement and mathematics academic performance, in the research on parental participation and mathematics learning motivation, it has been confirmed that internal motivation plays a linking role between parental participation and academic performance of third-grade students[25]. Specifically, when parents attach great importance to their children's mathematics learning and effectively participate in their educational process, children are more likely to overcome learning difficulties, maintain a high interest in

mathematics, and thereby improve their academic performance in mathematics. At the same time, primary school children are mainly characterized by being "active" and "playful". If parents can actively communicate with their children during their spare time, promptly identify their confusion, and "stimulate thinking through movement and arouse interest through play", they can promptly eliminate their fear of learning mathematics, and thus achieve good results in mathematics grades. Therefore, parents should strengthen the cultivation of their children's interest in learning mathematics to reduce the lack of learning motivation caused by the lack of strong learning interest.

On the other hand, parental behavioral involvement mainly relies on increasing children's expectations of self-education to indirectly promote students' mathematics learning. This result is consistent with that of the Regional National Education Longitudinal Study in the United States among eighth-grade students. That is, if parents can actively participate in the allocation of their children's study time, inquire about their children's performance at school, create a good learning atmosphere at home, and lead their children to know outstanding role models around them, then the proportion of students' expected investment and effort in learning will be increased[26]. This result is also in line with Coleman's social capital theory, which holds that the key for children to obtain cultural capital and social capital from their parents lies in the active participation and investment of the parents. Meanwhile, as the first teachers of their children, the educational values recognized by parents are the decisive factor for their children's educational expectations. Primary school children are in a critical period of development. The parenting styles and educational concepts of parents will eventually be internalized into the children's own learning views through family socialization, and then transform into their educational expectations. And as an motivating psychological factor, the higher the threshold of such expectations in children's psychology is, the more students will actively engage in their studies and strive to improve their academic performance[27]. Therefore, high expectations of self-education are the key to improving students' academic performance in mathematics.

4.3 Chain mediating effect

This study also found that there is a chain mediating effect between interest in mathematics learning and expectations of self-education and parental behavioral involvement and academic performance in mathematics. This result supports research Hypothesis 4. Specifically, when parents actively participate in their children's mathematics learning, such as providing academic tutoring and parent-child communication, these specific behaviors will indirectly enhance students' interest in mathematics, raise their expectations for self-education, and thereby encourage them to arrange their studies more systematically, effectively identify and solve the key and difficult points in learning, and thus improve their academic performance. This indicates that the behavioral involvement of parents is not only an important external driving force for improving academic performance in mathematics, but also a situational factor that has a positive impact on individual psychological motivations. From the perspective of child learning psychology, the active participation of parents in their children's education helps to stimulate the positive psychology of learners. A good family education environment and the words and deeds of parents have a significant promoting effect on students' individualized development and help cultivate children's positive psychological qualities[28]. This is the key to enhancing students' interest and expectations, alleviating anxiety in mathematics learning, overcoming fear of difficulties, improving concentration, and ultimately having a positive impact on students' academic performance in mathematics. In conclusion, this path highlights the chain mediating role of mathematics learning interest and self-education expectations. It not only reveals the interrelationship between parental behavioral involvement and mathematics academic performance, but also provides a reference for mathematics learning psychology.

5. Conclusions

This study verified the independent mediating effect and chain mediating effect of mathematics learning interest and self-education expectations between parental behavioral involvement of primary school students and mathematics academic performance, deepening the understanding of the influence mechanism between parental educational involvement and students' academic performance. The research finds that the behavioral involvement of parents of primary school students has a positive predictive effect on their academic performance in mathematics. Mathematics learning interest and self-education expectations respectively play a partially positive mediating role between parental behavioral involvement and mathematics academic performance. Mathematics learning interest and self-education expectations play a chain-like mediating role between parents' behavioral involvement and mathematics academic performance. These findings are of great significance to mathematics education, because the improvement of mathematics academic achievements cannot simply rely on the cultivation of schools, but also requires the comprehensive intervention of families and even society in students' mathematics learning.

This research is a cross-sectional study. The discovered relationships are based on the influence relationships of statistical

analysis. The conclusions of the obtained relationships still need to be verified by more rigorous educational experiments or follow-up studies. Furthermore, qualitative research methods such as case studies can be attempted to be applied to explore the relationships discovered in this study.

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