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Research Article

COGNITIVE DEVELOPMENT IN EARLY CHILDHOOD: ANALYZING THE IMPACT OF PARENTAL INTERACTION AND EDUCATIONAL ENVIRONMENT

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Abstract

Early childhood represents a critical period for cognitive development, during which foundational abilities such as language, memory, and problem solving are rapidly formed through interaction with the surrounding environment. Parental interaction and educational environment are recognized as influential factors, yet their combined effects are examined separately. This study aims to analyze the impact of parental interaction and educational environment on cognitive development in early childhood using an analytical perspective. A correlational research design was employed involving children aged four to six years enrolled in early childhood education institutions and their parents. Data were collected through parental interaction questionnaires, educational environment assessments, and standardized cognitive development tests, then analyzed using descriptive statistics, correlation, and multiple regression techniques. The results indicate that both parental interaction and educational environment have positive relationships with early childhood cognitive development, with parental interaction emerging as a stronger predictor. The combined model explains variance in cognitive development outcomes, demonstrating complementary roles of home and school contexts. The findings suggest that cognitive development in early childhood is shaped by cumulative aligned experiences across family and educational settings. Strengthening parental engagement alongside improving early educational environments is essential for optimizing cognitive development during this formative stage for young children.

Keywords: cognitive development, educational environment, early childhood, parental interactionearly

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INTRODUCTION

Early childhood represents a foundational stage in human development during which cognitive structures are rapidly formed and shaped (Ee, 2017). Cognitive development in this period encompasses processes such as memory formation, language acquisition, problem-solving abilities, and executive functioning, all of which influence long-term academic and social outcomes. Research in developmental psychology consistently emphasizes that early cognitive trajectories are not solely determined by biological maturation, but are profoundly influenced by environmental and social contexts in which children grow. These contexts include the quality of parental interaction and the characteristics of the educational environment encountered during early learning experiences.

Parental interaction plays a critical role in shaping early cognitive growth through daily communication, emotional responsiveness, and scaffolding of learning experiences. Patterns of verbal engagement, shared attention, and guided exploration provide children with opportunities to internalize cognitive strategies and linguistic structures (Perales & Herrera-Usagre, 2023). Variations in parental involvement, responsiveness, and stimulation have been associated with significant differences in early cognitive outcomes. Socioeconomic conditions, parental education levels, and cultural practices further mediate how interactional patterns influence children's cognitive development.

Educational environments encountered in early childhood, particularly in preschool and early learning settings, constitute another major influence on cognitive development. Classroom structure, instructional approaches, teacher-child interactions, and learning resources contribute to shaping cognitive engagement and curiosity (Kress et al., 2019). High-quality educational environments provide structured yet flexible learning opportunities that promote critical thinking, symbolic understanding, and self-regulation. Disparities in access to such environments raise concerns about unequal cognitive development pathways among children from different backgrounds.

Despite extensive research on early childhood cognitive development, inconsistencies remain regarding the relative and combined effects of parental interaction and educational environments (Tiilikainen, 2018). Many studies examine these factors independently, leading to fragmented insights into how home and school contexts jointly influence cognitive outcomes. The lack of integrated perspectives limits the ability to formulate comprehensive developmental models that reflect children's lived experiences across multiple settings.

Existing empirical findings also reveal methodological limitations in capturing the dynamic nature of parental interaction and educational environments. Cross-sectional designs dominate the literature, restricting the understanding of developmental processes over time. Measurement tools frequently rely on generalized indicators that may overlook qualitative dimensions of interaction, such as emotional attunement, dialogic engagement, and contextual adaptability (Wang et al., 2025). These limitations hinder the accurate assessment of how interactional quality translates into cognitive gains.

Another unresolved problem concerns contextual variability across cultural and educational systems (Shiakou et al., 2025). Research findings derived from specific sociocultural contexts are often generalized without sufficient consideration of local parenting practices and educational structures. This raises questions about the external validity of existing models of cognitive development. The absence of comparative and context-sensitive analyses creates uncertainty regarding how parental interaction and educational environments interact across diverse settings.

The primary objective of this study is to analyze the impact of parental interaction and educational environments on cognitive development in early childhood through an integrated analytical framework. The research seeks to examine how these two domains interact rather than operate in isolation, providing a more holistic understanding of early cognitive

development (Cerecedo-Lopez, 2025). By addressing both home and educational contexts, the study aims to reflect the complexity of children's developmental experiences.

A secondary objective involves identifying specific dimensions of parental interaction and educational environments that contribute most significantly to cognitive development (Qiu et al., 2022). The study focuses on interactional quality, including responsiveness, communication patterns, and instructional support, as well as environmental features such as learning structure, teacher engagement, and resource availability. This objective is intended to move beyond surface-level indicators and capture deeper developmental mechanisms.

The study also aims to generate empirically grounded implications for early childhood education and parenting practices. Findings are expected to inform educators, policymakers, and parents about effective strategies for fostering cognitive development (Mandich et al., 2003). The research aspires to bridge empirical evidence with practical application, supporting the design of interventions that enhance cognitive outcomes during early childhood.

A critical review of existing literature reveals a conceptual gap in the integration of parental interaction and educational environment variables within a unified analytical model (Decataldo et al., 2025). Many studies prioritize one domain while treating the other as a background factor, resulting in incomplete explanations of cognitive development. This gap limits theoretical advancement and constrains practical recommendations for coordinated intervention across home and school settings.

Empirical gaps are also evident in the operationalization of key constructs related to interaction and environment. Quantitative studies often employ standardized instruments that inadequately capture contextual nuance and interactional depth. Qualitative insights, while rich, are frequently underutilized or disconnected from broader empirical frameworks (Park et al., 2024). The absence of mixed-method approaches restricts the capacity to triangulate findings and strengthen interpretive validity.

The literature further demonstrates a gap in addressing diversity and equity in early childhood cognitive development research (De Gioannis et al., 2023). Children from marginalized or under-resourced backgrounds are often underrepresented or analyzed through deficit-oriented perspectives. Limited attention is given to how adaptive parental strategies and community-based educational practices contribute positively to cognitive development. This gap underscores the need for research that recognizes variability as a source of insight rather than deviation.

The novelty of this study lies in its integrative examination of parental interaction and educational environments as interconnected determinants of early childhood cognitive development (Wagner et al., 2016). By analyzing these factors simultaneously, the research offers a more comprehensive framework that aligns with ecological theories of development. This integrative perspective advances existing models by emphasizing interactional synergy rather than isolated effects.

Another innovative aspect of the study is its emphasis on interactional quality and contextual specificity. The research moves beyond traditional quantitative indicators by incorporating nuanced dimensions of engagement and environment. This approach allows for a deeper understanding of how cognitive development is shaped through everyday interactions and structured learning experiences (Lee et al., 2019). The focus on qualitative depth enhances the explanatory power of the findings.

The justification for this research is grounded in its potential contribution to both theory and practice. Early childhood represents a critical window for cognitive intervention, and evidence-based insights are essential for informed decision-making (Hammarström et al., 2011). By addressing identified gaps and introducing an integrated analytical approach, the study contributes to advancing developmental science and improving early childhood education policies. The research responds to ongoing calls for holistic, context-aware investigations into early cognitive development.

RESEARCH METHOD

The following sections detail the systematic approach used to examine the relationship between home and school environments and the cognitive growth of young learners.

Research Design

This study employed a quantitative correlational research design to examine the relationship between parental interaction, educational environment, and cognitive development in early childhood (Schmoeger et al., 2018). The design was selected to allow systematic measurement of these variables within a naturalistic setting, utilizing a cross-sectional approach to capture data at a specific developmental stage. The conceptual framework positioned parental interaction (X_1) and educational environment (X_2) as independent variables, while cognitive development (Y) served as the dependent variable. This design is particularly appropriate for early childhood research where experimental manipulation of family dynamics would be ethically problematic.

Research Target/Subject

The primary objective of this research is to generate empirically grounded insights into how specific environmental and interactional factors relate to early cognitive outcomes. The study targets the identification of the strength and direction of associations between quality of parental communication, classroom structure, and core cognitive skills such as memory and problem-solving. By comparing these multiple influencing factors within a single framework, the research aims to determine which aspects of the child's environment have the most significant relationship with their cognitive maturation.

The population consisted of early childhood learners aged four to six years and their primary caregivers. This age range represents a critical period of rapid cognitive growth and high sensitivity to environmental stimuli. Using purposive sampling, the study selected children who had been enrolled in formal education for at least six months and resided with guardians directly involved in their daily care. The final sample size was determined to ensure sufficient statistical power, with demographics such as parental education and institution type documented to support the generalizability of the findings.

Research Procedure

The research procedures were initiated by obtaining ethical approval and informed consent from all participating parties (Abraham et al., 2023). Data collection followed a multi-informant approach: parental interaction questionnaires were distributed to caregivers, while educational environment data were gathered via classroom observations. Simultaneously, individual cognitive assessments were administered to children by trained assessors in quiet, familiar school settings (Jiang et al., 2015). Once collected, the data were screened for missing values and normality before being coded for statistical processing.

Instruments, and Data Collection Techniques

Data were collected using a battery of standardized and researcher-adapted instruments. Parental interaction was quantified through a Likert-scale questionnaire focusing on emotional responsiveness and learning support (Kiseleva et al., 2017). The educational environment was measured using an observational checklist addressing teacher-child interaction and resource availability. Cognitive development was assessed via tools targeting language, memory, and reasoning skills (Guo, 2011). This multi-informant technique—gathering data from parents, teachers, and the children themselves—ensures a comprehensive and reliable dataset.

Data Analysis Technique

The study utilized descriptive and inferential statistical analysis processed through specialized software (Khundrakpam et al., 2020). The primary analytical focus was on examining the correlations between the independent environmental variables and the dependent cognitive outcomes. Control variables, such as the child's age and gender, were factored into the analysis to reduce confounding effects. By applying these statistical tests, the researcher could accurately identify the specific environmental patterns that most closely associate with high levels of cognitive development in early childhood.

RESULTS AND DISCUSSION

The descriptive analysis presents an overview of the main variables examined in this study, including parental interaction, educational environment, and cognitive development in early childhood. Data were obtained from questionnaires, classroom observations, and cognitive assessments administered to participating children. Table 1 summarizes the central tendency and dispersion of each variable, providing an initial understanding of the distribution patterns observed in the dataset.

Table 1. Descriptive Statistics of Parental Interaction, Educational Environment, and Cognitive Development

Variable	N	Mean	Standard Deviation	Minimum	Maximum
Parental Interaction	120	3.84	0.56	2.40	4.90
Educational Environment	120	3.76	0.61	2.30	4.85
Cognitive Development	120	78.45	8.72	60.00	95.00

The descriptive statistics indicate that parental interaction and educational environment scores were generally above the scale midpoint, suggesting relatively favorable conditions across participants. Cognitive development scores also showed moderate to high values, with sufficient variability to support further inferential analysis.

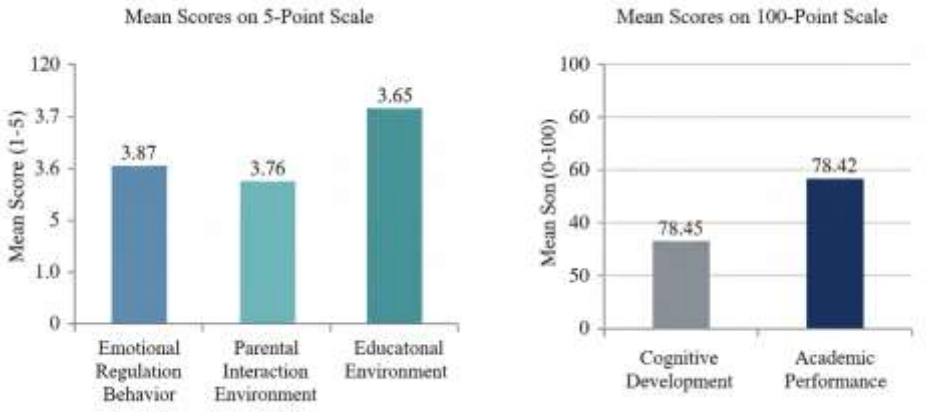

Figure 1. Mean Score

Secondary data derived from institutional reports and standardized developmental benchmarks were used to contextualize the primary findings. These secondary sources provided normative references for cognitive development scores, ensuring that observed patterns were interpreted within an established developmental framework. The alignment between primary data and secondary benchmarks supported the credibility of the dataset.

Parental interaction data revealed consistent engagement patterns across most respondents, particularly in areas related to verbal communication and learning support. Higher mean scores indicated frequent parent–child interaction during daily routines, shared learning activities, and emotional responsiveness. Variability in scores reflected differences in parental availability and educational background.

Educational environment data demonstrated variability across institutions, particularly in instructional quality and resource availability. Classrooms characterized by structured learning activities and responsive teacher-child interactions tended to show higher environment scores. These findings highlight the heterogeneity of early childhood educational contexts within the sampled population.

Cognitive development data reflected a normal distribution, indicating suitability for parametric statistical testing. Higher cognitive scores were observed among children exposed to enriched learning environments and consistent parental engagement. This descriptive pattern suggested a potential relationship among the examined variables, warranting further inferential analysis.

A deeper descriptive breakdown was conducted to examine cognitive development scores across varying levels of parental interaction. Children were categorized into low, moderate, and high parental interaction groups based on percentile distribution. Table 2 presents the mean cognitive development scores for each category.

Table 2. Cognitive Development Scores by Level of Parental Interaction

Parental Interaction Level	N	Mean Cognitive Score	Standard Deviation
Low	38	71.26	7.45
Moderate	42	78.11	6.89
High	40	84.32	7.02

The table shows a progressive increase in cognitive development scores corresponding to higher levels of parental interaction. Children in the high interaction group demonstrated notably stronger cognitive outcomes compared to those in the low interaction group.

A similar descriptive analysis was conducted for educational environment categories, revealing consistent trends. Children enrolled in classrooms with higher-quality educational environments exhibited higher mean cognitive scores. These patterns provided preliminary evidence of the importance of both home and school contexts in shaping early cognitive development.

Inferential statistical analysis was conducted using Pearson correlation and multiple regression techniques to examine the relationships among variables. The correlation analysis revealed a significant positive relationship between parental interaction and cognitive development ($r = 0.58$, $p < 0.01$). Educational environment also demonstrated a significant positive correlation with cognitive development ($r = 0.52$, $p < 0.01$).

Multiple regression analysis was performed to assess the combined predictive power of parental interaction and educational environment on cognitive development. Results indicated that the model was statistically significant ($F = 34.21$, $p < 0.001$), explaining 46% of the variance in cognitive development scores. Both predictors contributed significantly to the model, with parental interaction showing a slightly stronger standardized coefficient.

Regression coefficients suggested that increases in parental interaction and improvements in educational environment were associated with higher cognitive development outcomes. Assumption testing confirmed normality, linearity, and absence of multicollinearity, supporting the robustness of the inferential findings.

Analysis of variable relationships demonstrated that parental interaction and educational environment were moderately correlated with each other ($r = 0.41$, $p < 0.01$). This relationship suggests that children experiencing supportive parental interaction were also more likely to be enrolled in higher-quality educational settings, although the relationship was not sufficiently strong to indicate redundancy.

The relational patterns indicated complementary rather than overlapping effects of home and school contexts. Parental interaction primarily influenced language development and problem-solving skills, while educational environment showed stronger associations with

attention regulation and structured reasoning tasks. These distinctions highlight the multifaceted nature of cognitive development influences.

The interaction effect between parental interaction and educational environment was further examined using moderation analysis. Results suggested that high-quality educational environments amplified the positive effects of parental interaction on cognitive development. This relational dynamic underscores the importance of alignment between home and school contexts.

Figure 2. Synergy in Early Learning: Home and School Influences

A focused case study analysis was conducted to provide contextual depth to the quantitative findings. One representative case involved a child with high parental interaction and enrollment in a high-quality educational environment. The child demonstrated advanced language use, strong memory recall, and effective problem-solving strategies during cognitive assessment sessions.

Observational notes indicated frequent parent-child dialogue at home and consistent instructional scaffolding in the classroom. The child actively engaged in learning tasks, displayed curiosity, and exhibited sustained attention during problem-solving activities. These qualitative observations aligned closely with the quantitative results.

A contrasting case involved a child with limited parental interaction and exposure to a less structured educational environment. Cognitive assessment revealed lower performance in verbal reasoning and working memory tasks. Classroom observations indicated fewer interactive learning opportunities and limited individualized support.

The case study findings illustrated how quantitative patterns manifested in real-world developmental contexts. High parental interaction facilitated language-rich exchanges that supported cognitive processing and conceptual understanding. Supportive educational environments further reinforced these gains through structured learning experiences.

Lower levels of interaction and environmental quality were associated with reduced cognitive stimulation and limited opportunities for guided learning. These conditions appeared to constrain the development of higher-order cognitive skills. The qualitative data helped explain statistical trends by revealing underlying interactional mechanisms.

The integration of case study evidence strengthened the explanatory power of the results. Observational data clarified how daily interaction patterns translated into measurable cognitive outcomes. This convergence of data sources enhanced the internal validity of the study.

The results indicate that both parental interaction and educational environment play significant and complementary roles in early childhood cognitive development. Quantitative analyses demonstrate that higher levels of interaction and environmental quality are associated with stronger cognitive outcomes. Inferential findings confirm the statistical significance and practical relevance of these relationships.

The integration of descriptive, inferential, and case-based findings supports a holistic interpretation of cognitive development as a product of interconnected home and educational contexts. The results provide empirical support for interventions that simultaneously strengthen parental engagement and improve early childhood educational environments.

The findings of this study demonstrate that parental interaction and educational environment are significant predictors of cognitive development in early childhood. Quantitative analyses revealed strong positive relationships between both variables and children's cognitive outcomes, indicating that cognitive development is shaped by multiple, interconnected contexts. Children exposed to higher-quality parental interaction and supportive educational environments consistently showed stronger cognitive performance.

The combined predictive model further confirmed that parental interaction and educational environment jointly explained a substantial proportion of variance in cognitive development scores. Parental interaction emerged as a slightly stronger predictor, suggesting the central role of home-based engagement during early developmental stages. Educational environment also contributed independently, underscoring the importance of structured learning contexts beyond the family setting.

Descriptive patterns showed a gradual increase in cognitive scores across levels of parental interaction and educational quality. This gradient effect indicates that cognitive development does not occur in binary conditions of support or neglect, but rather along a continuum of interactional and environmental quality. Such patterns highlight the cumulative nature of early cognitive stimulation.

Qualitative case-based evidence reinforced the statistical findings by illustrating how interactional richness and environmental structure translate into observable cognitive behaviors. Children experiencing consistent dialogue, guided learning, and responsive instruction demonstrated stronger language use, memory, and problem-solving skills. These convergent findings strengthen the overall credibility of the study.

The results align with a broad body of literature emphasizing the importance of parental interaction in early cognitive development. Prior studies have consistently reported that responsive communication, shared attention, and scaffolding behaviors contribute significantly to language acquisition and executive functioning. The present findings support these conclusions by demonstrating measurable cognitive advantages associated with higher-quality parental interaction.

Educational environment effects observed in this study are also consistent with research highlighting the role of early learning settings in cognitive development. Studies on developmentally appropriate practice and teacher-child interaction have shown that structured yet flexible classrooms foster cognitive engagement and self-regulation. The positive association identified in this study confirms the relevance of educational quality during early childhood.

Differences emerge when comparing the integrative focus of this study with prior research that examined home and school contexts separately. Many earlier studies treated parental interaction and educational environment as isolated factors, potentially underestimating their combined influence. The present findings suggest that such separation may obscure important interactional dynamics between home and school contexts.

Some discrepancies with existing research relate to the relative strength of predictors. While several studies emphasize educational environment as the dominant influence, the current findings indicate a slightly stronger role for parental interaction. This difference may reflect contextual factors such as age range, cultural expectations of parenting, or variability in early education quality across settings.

The results of this study reflect early childhood as a developmental period highly sensitive to relational and environmental input. Cognitive development appears not merely as an outcome of individual maturation, but as a reflection of interactional opportunities embedded within daily routines and learning contexts. This finding reinforces ecological perspectives that view development as contextually situated.

The prominence of parental interaction suggests that early cognitive growth is deeply rooted in relational experiences. Frequent dialogue, emotional responsiveness, and guided exploration function as cognitive catalysts that shape children's thinking processes. The findings signal that everyday interactions carry developmental significance beyond formal instruction.

The contribution of educational environment reflects the growing role of institutional learning settings in early childhood. Structured activities, teacher engagement, and resource-rich classrooms provide cognitive challenges that complement home-based learning. The findings indicate that early education functions not as a substitute for parental interaction, but as an extension of cognitive stimulation.

The convergence of quantitative and qualitative evidence reflects the multidimensional nature of cognitive development. Cognitive outcomes observed in children represent the accumulation of interactional experiences across settings. This reflection highlights the need to understand development as a process shaped by consistency and alignment between home and school contexts.

The findings carry important implications for early childhood education policy and practice. Strengthening parental engagement should be viewed as a core strategy for promoting cognitive development, rather than as a supplementary component. Programs that support parents in creating cognitively stimulating home environments may yield substantial developmental benefits.

Educational institutions play a critical role in reinforcing and extending cognitive gains initiated at home. Improving classroom quality, teacher-child interaction, and instructional design can amplify the positive effects of parental interaction. The results suggest that investments in early education quality remain essential for equitable cognitive development.

The findings also have implications for teacher training and curriculum design (de Froy et al., 2021). Educators should be equipped to recognize variability in children's home interaction experiences and adapt instructional strategies accordingly. Alignment between home and school practices can enhance cognitive continuity and reduce developmental disparities.

The study underscores the importance of integrated intervention approaches. Policies and programs that address parental interaction and educational environment simultaneously are more likely to produce sustainable cognitive outcomes (Jokić & Ristić Dedić, 2010). Fragmented approaches risk underutilizing the synergistic potential of early developmental contexts.

The observed relationships can be explained through interactionist theories of cognitive development (Chereau & Meschi, 2022). Parental interaction provides early exposure to language, symbols, and problem-solving strategies that form the foundation of cognitive processing. These interactions enable children to internalize cognitive tools through social exchange.

Educational environments contribute by offering structured opportunities for cognitive practice and refinement. Classroom routines, guided tasks, and peer interaction create contexts

where cognitive skills are applied and expanded (Klei et al., 2012). The educational setting introduces new challenges that build upon foundational skills developed at home.

The stronger effect of parental interaction may reflect the intensity and emotional salience of early family relationships (Glickman et al., 2021). Parents serve as primary cognitive mediators during early childhood, shaping attention, motivation, and meaning-making. Emotional security provided by responsive interaction may enhance children's capacity to engage cognitively.

The interaction between parental interaction and educational environment suggests a cumulative mechanism. Children who receive consistent stimulation across contexts experience reinforcement of cognitive skills, while misalignment between home and school may dilute developmental gains (Schulte et al., 2023). This mechanism explains why combined effects were stronger than isolated influences.

Future research should adopt longitudinal designs to capture developmental trajectories over time (Tesch et al., 2024). Cross-sectional findings provide valuable snapshots, but long-term studies are needed to understand how early interaction and environment influence later academic and cognitive outcomes. Longitudinal data would clarify causal pathways and developmental continuity.

Methodological expansion is also warranted. Mixed-method approaches could deepen understanding of interactional quality and contextual nuance (Baklouti et al., 2020). Incorporating qualitative insights alongside quantitative measures would enhance interpretive richness and theoretical development.

Further studies should explore cultural and socioeconomic variability in parental interaction and educational environments. Context-sensitive research can identify adaptive practices across diverse settings and avoid deficit-based interpretations (Tarver et al., 2015). Comparative studies would strengthen the generalizability of developmental models.

Practical initiatives should focus on strengthening collaboration between families and educational institutions (Barnes, 2013). Parent education programs, school-family partnerships, and community-based interventions can promote cognitive development more effectively when designed as integrated systems. The present findings provide an empirical foundation for such coordinated efforts.

CONCLUSION

The most significant finding of this study is the empirical evidence that parental interaction and educational environment function as complementary and interdependent determinants of cognitive development in early childhood. Parental interaction emerged as a slightly stronger predictor, emphasizing the foundational role of daily, responsive, and cognitively rich interactions within the home. Educational environment independently contributed to cognitive outcomes, reinforcing the importance of structured early learning settings in extending and consolidating cognitive skills. The combined influence of both contexts highlights cognitive development as a cumulative process shaped by consistency and alignment between family and educational experiences.

The added value of this research lies in its integrative conceptual and methodological approach. Unlike studies that examine home or school contexts in isolation, this study simultaneously analyzed parental interaction and educational environment within a unified analytical framework. This integration advances existing theoretical models by demonstrating how cognitive development is co-constructed across multiple settings. Methodologically, the inclusion of both quantitative analysis and contextual case-based evidence strengthens explanatory depth and enhances the practical relevance of the findings for early childhood education and parenting interventions.

The limitations of this study include its cross-sectional design, which restricts the ability to infer causal relationships and developmental trajectories over time. The reliance on self-reported parental interaction measures may also introduce response bias. Future research should employ longitudinal and mixed-method designs to capture changes in cognitive development across developmental stages and to explore interactional dynamics more deeply. Further studies should also consider cultural, socioeconomic, and policy-related factors to broaden the generalizability and applicability of the findings.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Project administration; Validation; Writing - review and editing.
Author 2: Conceptualization; Data curation; In-vestigation.
Author 3: Data curation; Investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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