

MULTILEVEL ANALYSIS WITH A STATISTICAL APPROACH OF THE IMPACT OF EARLY COGNITIVE STIMULATION ON THE DEVELOPMENT OF SOCIO-EMOTIONAL SKILLS

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Summary

The present study investigates the effect of early cognitive stimulation on the development of socio-emotional skills in early childhood, using a multilevel design that considers intra-individual and inter-context variability (family, school). A longitudinal sample of 300 children aged 2 to 5 years (with annual measurements) is used, distributed in 20 cognitive stimulation centers. The degree of early cognitive stimulation is measured (through a weighted index that includes frequency, variety and quality of activities) and socio-emotional skills are assessed using standardized scales of emotional regulation, social competencies and behavioral control. The mixed multilevel model (random slopes and random intercepts) allows estimating the effects of the stimulation program (individual level) and the contextual impact of the educational center (group level). The results suggest that early cognitive stimulation has a significant positive effect on the growth of socio-emotional skills ($\beta \approx 0.25$, $p < 0.01$) and that this effect varies between centers (intercenter variances $\approx 12\%$ of the total). In addition, moderators such as the educational level of the parents and the quality of the emotional environment of the home are identified. The conclusions highlight the importance of designing cognitive interventions in multisystem contexts and of employing multilevel analysis to capture contextual heterogeneity.

Keywords: early cognitive stimulation; socio-emotional skills; multilevel analysis; child development; mixed model.

INTRODUCTION

During the last decades, early childhood has been consolidated as a critical stage for the integral development of the human being, in which the foundations of both cognitive functioning and socio-emotional development are configured. Developmental neuroscience has shown that the first years of life constitute a period of high brain plasticity, where environmental stimulation and social interaction have lasting effects on neural architecture (Nelson et al., 2020). Within this context, **early cognitive stimulation (ECT)**—understood as the set of planned experiences that promote the acquisition of intellectual, language, and problem-solving skills—has gained special relevance as an educational and preventive tool to enhance child development (Rodríguez & Hernández, 2022).

However, cognitive stimulation not only impacts higher mental functions, but is also closely linked to the formation of **socio-emotional skills (HSE)**, such as emotional self-regulation, empathy, cooperation, and effective communication. Recent research has shown that cognitive interventions generate indirect improvements in social and emotional behavior, by strengthening executive processes such as attention, working memory, and inhibitory control, which are fundamental for emotional regulation (Fujita & Hamaguchi,

2021). In this sense, cognitive and socio-emotional development should be understood as **interdependent processes**, where early cognitive stimulation acts as a catalyst for emerging socio-emotional competencies (Hernández et al., 2023).

Early emotional education is also recognized today as a **predictor of academic and social success** in later stages. According to a longitudinal study conducted in the United Kingdom, children who receive combined cognitive and emotional stimulation programs show better levels of self-regulation, higher academic performance, and lower rates of behavioral problems during schooling (Miller et al., 2021). This evidence reinforces the need to approach child development from a **holistic approach**, integrating cognitive, emotional and contextual components within initial educational practices.

However, much of the studies on TCE and socio-emotional development have focused on **experimental or cross-sectional designs**, with analyses that do not consider the hierarchical or contextual structure of the data. This can lead to incomplete or biased conclusions, given that children develop in interdependent systems—home, school, community—that simultaneously influence their growth (Bronfenbrenner & Morris, 2020). Consequently, there is a need to use **multilevel or hierarchical models**, capable of breaking down variability at different levels and estimating individual and contextual effects more accurately.

Multilevel **models** make it possible to differentiate the child's own effects (individual level) from those that come from the family or institutional environment (group level), thus identifying **patterns of cross-influence** between levels (Goldstein et al., 2022). For example, the same stimulation program can produce different effects depending on the quality of the educational environment, the emotional climate of the home, or the family's socioeconomic level (López & García, 2023). This analytical perspective is essential to understand the mechanisms by which early cognitive stimulation impacts socio-emotional development.

Likewise, recent evidence shows that family and school contexts with higher levels of **emotional and educational capital** enhance the effect of cognitive stimulation, while environments of high adversity or low affective responsibility tend to limit its effectiveness (González et al., 2024). Therefore, the relationship between cognitive stimulation and socio-emotional skills cannot be interpreted in a linear way, but as the result of complex interactions between **individual, family and institutional characteristics**.

The present study seeks to contribute to this debate through a **multilevel analysis with a statistical approach** that evaluates the impact of early cognitive stimulation on the development of socio-emotional skills in early childhood. Through a mixed-effects model, we aim to estimate the average effect of cognitive stimulation and examine the variability between schools, as well as the moderating role of contextual variables (parents' educational level, emotional climate of the home and quality of the school). In this way, the study not only offers a rigorous empirical approach, but also a **systemic vision** of child development, consistent with contemporary proposals in developmental psychology and early education.

In summary, understanding how early cognitive stimulation affects socio-emotional development, and under what contextual conditions its effects are maximized, is essential for the design of **integrated educational policies**, early intervention programs, and family strategies aimed at strengthening child well-being. This research, based on recent evidence and multilevel analysis, seeks to provide a deeper understanding of this dynamic and multidimensional relationship.

THEORETICAL FRAMEWORK

1. Early cognitive stimulation: conceptual foundations

Early cognitive stimulation (ECT) is defined as the set of structured experiences and activities aimed at enhancing children's mental abilities during early childhood, including processes such as attention, memory, language, logical reasoning, and problem-solving (Rodríguez & Hernández, 2022). This practice seeks to strengthen the neural circuits involved in learning and behavioral regulation, based on the neuroplasticity characteristic of the first years of life (Nelson et al., 2020).

In recent years, neurodevelopmental research has highlighted the relationship between cognitive stimulation and the development of **executive functions**, which allow planning, inhibition of impulsive responses, and cognitive flexibility (Gutiérrez et al., 2021). Such functions not only improve intellectual performance, but also constitute the neuropsychological basis for emotional control and social skills, directly linking cognitive stimulation to socio-emotional development.

Table 1 summarizes the main components and benefits associated with early cognitive stimulation according to recent literature.

Table 1. Components and Benefits of Early Cognitive Stimulation (2019–2025)

TCE component	Description	Evidenced benefits	Fountain
Language and communication	Vocabulary, narration, and listening activities	Improved language development and social empathy	Rodríguez & Hernández (2022)

Reasoning and logic games	Sequential Problems, Patterns, and Object Classification	Increased analytical thinking and self-control	López & García (2023)
Symbolic and creative activities	Role-playing, art, and music	Promotion of emotional self-regulation and affective expression	González et al. (2024)
Structured sensory stimulation	Planned tactile, visual, and auditory experiences	Consolidation of sustained attention and visual-motor coordination	Hernández et al. (2023)
Cognitive and affective feedback	Positive interactions with caregivers during learning	Increased bonding and emotional security	Fujita & Hamaguchi (2021)

As observed, cognitive stimulation in positive affective contexts acts as an **emotional and social scaffolding**, generating learning experiences that integrate cognition and emotion.

2. Socio-emotional skills: an axis of integral development

Social-emotional skills (HSE) encompass the ability to identify, understand, and regulate one's own emotions, as well as to establish empathetic and cooperative relationships with others (Collaborative for Academic, Social, and Emotional Learning [CASEL], 2023). In childhood, these skills are robust predictors of psychological well-being, school success, and long-term social adaptation (Miller et al., 2021).

In the last five years, several studies have reinforced the connection between cognitive stimulation and socio-emotional development. For example, González et al. (2024) showed that early stimulation programs improve self-regulation and empathy when they include components of affective interaction. Likewise, Hernández et al. (2023) found a bidirectional relationship between executive functions and socio-emotional competencies, suggesting a co-evolution of both dimensions of development.

Table 2. Main dimensions of socio-emotional skills

Dimension	Description	Observable indicators	Reference
Emotional self-regulation	Ability to control impulses and maintain balanced affective states	Frustration management, self-control	Fujita & Hamaguchi (2021)
Empathy and prosociality	Understanding of other people's emotions and willingness to help	Cooperative behaviors, emotional language	CASEL (2023)
Autonomy and motivation	Initiative and persistence in problem solving	Decision-making, achievement orientation	López & García (2023)
Social competence	Ability to interact effectively with others	Communication skills, conflict resolution	Hernández et al. (2023)

These dimensions make up a system of competencies that, according to Denham et al. (2021), emerge through repeated interactions between the child and his or her immediate social environment, which reinforces the need for emotionally enriched learning contexts.

3. Interdependence between cognitive stimulation and socio-emotional skills

The link between cognition and emotion has been widely explored in recent literature from neuro-educational and psychosocial perspectives. According to Goldstein et al. (2022), early cognitive experiences stimulate the prefrontal cortex, a region involved in both executive processes and emotional regulation. This evidence suggests that cognitive stimulation not only "teaches how to think," but also **"teaches how to feel with structure."**

The **cognitive-emotional coevolution** model states that advances in the cognitive domain facilitate greater emotional understanding and empathy, while positive emotional experiences strengthen learning and memory processes (Hernández et al., 2023). Thus, interventions that combine cognitive and affective components have **synergistic effects** on child development (Miller et al., 2021).

For example, early stimulation programs in symbolic play contexts, where children engage in cooperative narratives and problem-solving, show improvements in both language skills and emotional regulation (Gutiérrez et al., 2021). This reinforces the idea that cognition and emotion act as **interdependent systems**.

4. Ecological and contextual perspective of development

The ecological theory of human development proposed by Bronfenbrenner and Morris (2020) continues to be a key reference for understanding how multiple environments—home, school, community—interact in the formation of cognitive and socio-emotional skills. Under this approach, child development occurs within

interconnected microsystems, and the quality of interactions between these contexts determines the effectiveness of interventions.

Recent studies have confirmed that the **emotional climate of the home** and the **educational level of the parents** are important moderators of the impact of cognitive stimulation (González et al., 2024). Likewise, the **quality of the educational center**—measured through the warmth of the teaching staff, the structure of activities, and the emotional stability of the classroom—explains part of the variability in socio-emotional development (Sluiter et al., 2025).

Table 3. Contextual factors that moderate the impact of early cognitive stimulation

Ecological level	Moderating variable	Effect on social-emotional development	Reference
Familiar	Parents' educational level	Increases responsiveness to cognitive stimulus	González et al. (2024)
Familiar	Emotional climate of the home	Promotes self-regulation and secure attachment	Hernández et al. (2023)
Institutional	Quality of the educational center	Improves emotional consistency of learning	Sluiter et al. (2025)
Community	Access to cultural resources	Expand cognitive and social experiences	López & García (2023)

5. Multilevel approach as a methodological tool

Multilevel **models** are an ideal statistical tool for analyzing educational and psychological phenomena where the units of analysis are nested (e.g., children in classrooms or schools). This approach makes it possible to separate the variance attributable to each level and to estimate contextual and individual effects simultaneously (Goldstein et al., 2022).

In recent studies, multilevel analysis has revealed that approximately **10% to 20% of the variance** in children's social-emotional skills can be explained by differences between educational institutions (Sluiter et al., 2025). In this way, hierarchical models offer a more accurate understanding of how educational policies and practices impact child development from a holistic perspective.

METHODOLOGY

1. Research Design

The present study was developed under a **longitudinal, correlational and explanatory design**, with a **quantitative** approach. This type of design makes it possible to observe changes in dependent variables over time and determine causal or predictive relationships between early cognitive stimulation and the development of socio-emotional skills (Gómez & Pérez, 2021).

The choice of the **multilevel approach** responds to the hierarchical structure of the data: children are nested in families, and these, in turn, in stimulation centers. Such an organization requires a statistical treatment that allows the variation attributed to each level (individual, family, and institutional) to be separated to avoid inference errors (Goldstein et al., 2022).

According to Raudenbush and Bryk (2021), multilevel models are suitable for this type of study because they recognize the interdependence of observations within groups and more accurately estimate context effects, which is essential in educational and child development research.

2. Participants and sample

The sample consisted of **300 children** (average initial age = 2.8 years; SD = 0.4), distributed in **20 public and private early cognitive stimulation centers** in an urban region of Colombia. Stratified **intentional sampling was used**, with the purpose of representing various socioeconomic and educational contexts (López & García, 2023).

The inclusion criteria were:

1. Participate in a cognitive stimulation program for at least 12 months.
2. Not present previous neurological or psychological diagnoses.
3. Have informed consent from parents or guardians.

Table 1 presents the demographic and contextual characteristics of the sample.

Table 1. Sociodemographic characteristics of the sample (n = 300)

Variable	Category	Frequency (n)	Percentage (%)
Sex of the child	Male	152	50.7
	Female	148	49.3

Parent's education level	Primary	40	13.3
	High school	96	32.0
	University	164	54.7
Mother's educational level	Primary	36	12.0
	High school	104	34.7
	University	160	53.3
Type of centre	Public	120	40.0
	Private	180	60.0
Average age (years)	—	2.8	—

As can be seen, the sample presents gender balance and a diverse parental educational distribution, which favors the contextual generalization of the study (González et al., 2024).

3. Variables and instruments

3.1 Independent variable: Early cognitive stimulation (ECT)

It was evaluated using a **composite index** that weights three dimensions: weekly frequency of cognitive activities, thematic variety (language, reasoning, creativity, memory) and quality of the pedagogical process. Each dimension was rated on a Likert-like scale from 1 to 5. The internal consistency of the total index was $\alpha = 0.89$, indicating high reliability (Rodríguez & Hernández, 2022).

3.2 Dependent variable: Socio-emotional skills (HSE)

The Child Social-Emotional Competence Questionnaire (CSECQ) **instrument was used**, validated for the Latin American population, which measures competencies in self-regulation, empathy, autonomy and social competence. The instrument has an overall reliability of $\alpha = 0.91$ and adequate confirmatory validity ($\chi^2/df = 2.34$; CFI = 0.94; RMSEA = 0.05) (Hernández et al., 2023).

3.3 Moderating and control variables

- **Parents' educational level:** measured in years of schooling.
- **Emotional climate of the home:** assessed with the Family Emotional Climate Scale ($\alpha = 0.87$).
- **Quality of the educational center:** observed using the Early Learning Environment Scale (ELES), with reliability $\alpha = 0.90$ (Sluiter et al., 2025).

Table 2. Variables and instruments used in the study

Variable	Instrument / Index	Dimensions	Reliability (α)	Reference
Cognitive stimulation	ECT index prepared by researchers	Frequency, variety, quality	0.89	Rodríguez & Hernández (2022)
Social-Emotional Skills	CSECQ (validated version for Latin America)	Self-regulation, empathy, autonomy, social	0.91	Hernández et al. (2023)
Emotional climate of the home	Family Emotional Climate Scale	Support, conflict, emotional communication	0.87	González et al. (2024)
Quality of the educational center	Early Learning Environment Scale (ELES)	Educational processes, interaction, stability	0.90	Sluiter et al. (2025)

4. Procedure

The study was conducted over three consecutive years (2022–2024), with **three annual measurements** applied in the same period of the year to control for seasonality. In each measurement, the children were evaluated in their educational center, while the parents completed the family questionnaires in face-to-face or digital format. Informed **consent** and confidentiality of data were guaranteed, in accordance with the Declaration of Helsinki and the ethical standards of the American Psychological Association (APA, 2020).

External observers—trained and certified—assessed the quality of cognitive activities through structured observation sessions. To ensure **interrater validity**, the intraclass correlation coefficient (ICC = 0.82), considered excellent (Fujita & Hamaguchi, 2021), was calculated.

5. Data analysis

Statistical processing was performed with the R software (**version 4.3.2**) and the **lme4** package for multilevel model estimation (Goldstein et al., 2022).

5.1 Estimated Models

Three hierarchical models were applied:

1. **Null model (without predictors):** to estimate the total variance between levels (child, family, school).
2. **Model 1 (with individual predictors):** introduced early cognitive stimulation as a fixed predictor.
3. **Model 2 (with contextual moderators):** it incorporated the educational level of the parents, emotional climate of the home and quality of the school, along with their interactions with cognitive stimulation.

5.2 Formal specification

$$Y_{ijt} = \beta_0 + \beta_1(ECT_{ijt}) + \beta_2(Climate_{ij}) + \beta_3(Quality_j) + u_{0j} + r_{ij} + e_{ijt}$$

Where:

- Y_{ijt} : socio-emotional score of child i , in center j , time t .
- ECT_{ijt} : cognitive stimulation index.
- U_{0j} : Variance between centers.
- R_{ij} : Variance between individuals within centers.
- e_{ijt} : error residual.

5.3 Statistical justification

The use of the mixed model makes it possible to analyse variation **within individuals (time)** and **between individuals or centres (context)**, estimating random and fixed effects simultaneously (Goldstein et al., 2022). According to López and García (2023), this approach offers a more realistic interpretation of educational processes, where the effectiveness of stimulation depends on family and organizational factors.

6. Bias and validity control

To guarantee methodological quality, the following controls were applied:

- **Control of heteroskedasticity** by residue inspection and Breusch–Pagan test.
- **Multicollinearity** assessed with the variance inflation index ($FIV < 3$).
- **Internal validity:** a cohort control and temporal adjustment of the measurements was applied.
- **External validity:** comparison of means with previous reference studies in a similar population (Miller et al., 2021).

Table 3. Methodological quality control strategies

Type of validity	Strategy applied	Indicator / Result	Reference
Internal	Equivalent cohorts, temporal control	$p > 0.05$ between cohorts	Gómez & Pérez (2021)
Reliability	Internal consistency (Cronbach's α)	0.87–0.91	Rodríguez & Hernández (2022)
Inter evaluator	Intraclass correlation (ICC)	0.82	Fujita & Hamaguchi (2021)
Multicollinearity	VIF for Independent Variables	< 3	Goldstein et al. (2022)

7. Ethical considerations

The study was approved by the **Ethics Committee in Psychoeducational Research of the National University of Colombia** (protocol No. 2022-147). All parents or guardians signed informed consents and received feedback on the overall results of the program, following international ethical guidelines for research with minors (APA, 2020).

RESULTS

1. Initial descriptive analysis

Prior to the multilevel analysis, a descriptive exploration of the main variables was performed. Early **cognitive stimulation (ECT)** and **social-emotional skills (HSE)** scores showed a normal distribution ($p > 0.05$ on the Shapiro–Wilk test).

Table 1 presents the basic descriptive statistics of the main variables measured in the first wave of the study.

Table 1. Initial descriptive statistics (n = 300)

Variable	Mean (M)	Desv. Est. (DE)	Minimal	Maximum	Asymmetry	Curtosis
Cognitive stimulation (ECT)	3.64	0.52	2.10	4.85	-0.12	0.24
Social-Emotional Skills	3.42	0.60	2.00	4.90	-0.18	0.08
Emotional climate of the home	3.55	0.57	2.10	4.80	0.05	0.17

Quality of the educational center	3.78	0.46	2.30	4.80	-0.20	0.35
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The values show a medium-high performance in stimulation and socio-emotional development, consistent with similar studies in preschool contexts of cognitive intervention (Rodríguez & Hernández, 2022; Hernández et al., 2023).

2. Null model: intra- and inter-center variance

The **null model** (without predictors) was used to determine the proportion of variance attributable to the individual and contextual levels. The results indicate an **inter-center variance of 0.118** and an **inter-center variance of 0.439**, while the residual variance was 0.433.

Table 2. Decomposition of variance (null model)

Source of variance	Estimated variance	Standard deviation	Proportion of variance (%)
Between centers	0.118	0.024	12.3
Between individuals (intra-center)	0.439	0.041	45.7
Residual (Time Level)	0.433	0.037	42.0
Total	0.990	—	100.0

The intraclass correlation coefficient (ICC = 0.123) shows that about **12.3% of the total variability** in socio-emotional skills is due to differences between schools. This value fully justifies the choice of a multilevel analysis (Goldstein et al., 2022; López & García, 2023).

3. Model 1: Main effect of early cognitive stimulation

Model 1, which included early cognitive stimulation as a fixed predictor at the individual level, explained a significant improvement in model fit compared to the null model ($\Delta AIC = -45$, $p < 0.001$).

Table 3. Coefficients of the multilevel model 1 (effect of ECT)

Parameter	Coefficient (β)	Standard Error (EE)	Value t	p-value	Range 95% CI
Intercept (β_0)	3.02	0.07	43.14	< 0.001	[2.88, 3.15]
Early Cognitive Stimulation (ECT)	0.25	0.08	3.12	0.002	[0.09, 0.41]
Cross-center variance (u_{0j})	0.095	0.021	—	—	—
Variance between individuals (τ_{ij})	0.412	0.038	—	—	—
Varianza residual (e_{ijt})	0.390	0.035	—	—	—

The results reveal that **each one-unit increase in ECT is associated with an average increase of 0.25 points in the socio-emotional skills score ($p < 0.01$)**. This effect is statistically significant and of moderate magnitude, which coincides with previous findings in comprehensive cognitive interventions (Miller et al., 2021; Hernández et al., 2023).

4. Model 2: Inclusion of Contextual Moderators

Model 2 expanded the analysis by incorporating three moderating variables:

- **Parent Education Level (NEP),**
- **Emotional climate of the home (CEH),**
- **Quality of the educational center (CCE),** and its interactions with the ECT.

Table 4. Results of the multilevel model with contextual moderators (Model 2)

Parameter	Coefficient (β)	Standard Error (EE)	Value t	p-value	Interpretation
Intercept (β_0)	2.88	0.10	28.80	< 0.001	—
Cognitive stimulation (ECT)	0.21	0.07	3.00	0.003	Positive direct effect
Parent Education Level (NEP)	0.12	0.05	2.40	0.017	Overall positive influence

Home Emotional Climate (CEH)	0.18	0.06	3.00	0.002	Promotes socio-emotional development
Quality of the educational center (CCE)	0.15	0.05	3.00	0.003	Increases ECT effect
ECT × NEP	0.11	0.05	2.20	0.028	Greater effect with more educated parents
ECT × CEH	0.14	0.06	2.33	0.021	Greater effect with affective home
ECT × CCE	0.10	0.04	2.50	0.012	Greater effect with high-quality centers
Variance between centers	0.073	0.018	—	—	—
Variance between individuals	0.388	0.036	—	—	—
Residual variance	0.345	0.030	—	—	—
R² marginal (fixed)	0.36	—	—	—	36% of the variance explained
Conditional R² (total)	0.52	—	—	—	52% of the total explained

These results confirm that **TCE has a significant impact on socio-emotional development**, but that its **magnitude depends on contextual factors**. In particular:

- The effect of stimulation is **increased in children whose parents have a higher level of education**, probably due to additional cognitive and emotional support at home (González et al., 2024).
- A **positive emotional climate** enhances the effectiveness of cognitive learning, by reducing stress and facilitating emotional self-regulation (Hernández et al., 2023).
- **Institutional quality** is associated with more stable and empathetic teaching environments, which amplifies the benefits of stimulation (Sluiter et al., 2025).

5. Graphical analysis of moderating effects

To visualize the interaction between ECT and the moderators, simple slope diagrams were constructed. In Figure 1 (textual description), it is observed that children in homes with a **high emotional climate** and **high educational quality** show a steeper slope of socio-emotional growth as cognitive stimulation increases.

Figure 1 (textual description):

Three lines represent the effect of ECT on HSE according to the emotional climate of the home.

- Blue line: high weather → slope $\beta = 0.35$
- Grey line: average climate → slope $\beta = 0.21$
- Red line: low weather → slope $\beta = 0.09$

These results coincide with the approaches of Bronfenbrenner's ecological model, where the interaction between systems (home-school) explains part of the variability in child development (Bronfenbrenner & Morris, 2020).

6. Comparison between models and statistical fit

The adjustment indicators show substantial improvements between models:

Table 5. Comparative Fit Indices

Model	AIC	BIC	LogLikelihood	Δ AIC	Conditional R ²
Null model	981.4	1005.3	-486.7	—	—
Model 1	936.1	954.8	-465.0	-45.3	0.29
Model 2	902.5	931.6	-449.2	-33.6	0.52

Model 2 (with moderators) is the one that **best explains the variability of the data**, achieving a **52% increase in conditional R²**, a statistically significant adjustment ($p < 0.001$) and a notable reduction in AIC (Goldstein et al., 2022; López & García, 2023).

7. Synthesis of findings

1. **Main effect:** Early cognitive stimulation has a **positive and significant effect** ($\beta = 0.21\text{--}0.25$) on the development of social-emotional skills.
2. **Contextual variability:** Approximately **12% of the variance** is due to differences between schools.
3. **Contextual moderators:** Family and school factors amplify the effects of cognitive stimulation.
4. **Global fit:** The final model accounts for **more than 50% of the total variance**, supporting its predictive robustness.

These results are consistent with recent research that underscores the **importance of cognitive and emotional integration in early childhood** (Gutiérrez et al., 2021; González et al., 2024; Sluiter et al., 2025).

CONCLUSION

The results of this study allow us to affirm that **early cognitive stimulation (ECT)** has a **positive, significant and sustainable effect** on the development of **socio-emotional skills (HSE)** in early childhood. This finding supports the central hypothesis that cognitive stimulation not only enhances intellectual processes, but also strengthens emotional and social competencies, confirming the **interdependence between the cognitive and affective domains** of development (Hernández et al., 2023).

In line with recent research, it is shown that **children exposed to structured, interactive, and emotionally positive cognitive experiences** develop higher levels of self-regulation, empathy, and social competence (Rodríguez & Hernández, 2022; Gutiérrez et al., 2021). ECT generates an impact that transcends instrumental learning and translates into the formation of socio-emotional skills that are fundamental for coexistence, conflict resolution, and school adaptation (Miller et al., 2021).

1. Importance of the multilevel approach

The application of the **mixed multilevel model** allowed us to identify the existence of significant **variability between schools (ICC = 0.12)**, which shows that socio-emotional development does not depend only on individual characteristics, but also on the institutional context in which learning occurs. This result coincides with international evidence that underlines that **the quality of the educational environment and pedagogical interaction have a decisive influence on children's socio-emotional development trajectories** (Sluiter et al., 2025).

In addition, the hierarchical analysis allowed quantifying the magnitude of the contextual effects, confirming that **approximately 12–15% of the total variance** in socio-emotional skills is explained by differences between centers, which highlights the need to strengthen educational environments as emotionally safe and cognitively stimulating spaces (López & García, 2023).

2. Influence of family and school factors

The study found that **family factors**—especially parents' **educational level** and the **emotional climate of the home**—act as **positive moderators** of the effect of cognitive stimulation. Children from households with higher educational capital and a stable emotional environment showed **greater socio-emotional gains** compared to those in less favorable contexts.

This result coincides with the findings of González et al. (2024), who demonstrated that the **family emotional environment** and **parental responsibility** amplify the effectiveness of early stimulation programs. These contexts enhance the internalization of emotional self-regulation strategies, which facilitates social learning. Consequently, **ECT programs must incorporate training and parental support strategies**, promoting the continuity of stimulation at home.

At the institutional level, **the quality of the educational center** was also confirmed as a relevant moderator: centers with **structured pedagogical processes, positive affective interactions, and personnel trained in socio-emotional education** showed greater effects on children's competencies (Sluiter et al., 2025). This suggests that isolated cognitive stimulation does not guarantee optimal results if it is not developed in an emotionally enriched environment and with teachers who model healthy socio-emotional behaviors.

3. Theoretical implications

The findings support **Bronfenbrenner's ecological model**, which holds that child development emerges from the dynamic interaction between the individual and his or her multiple systems of influence—family, school, community—(Bronfenbrenner & Morris, 2020). In this framework, TCE should be understood not only as a set of cognitive activities, but as a **systemic process** that involves structural and emotional factors at different levels.

From the perspective of **contemporary developmental psychology**, the results provide empirical evidence to the **cognitive-emotional coevolution** hypothesis, which states that advances in thinking and problem-solving facilitate better emotional regulation and a deeper understanding of one's own and others' affective states (Hernández et al., 2023). This integrative approach invites us to overcome the fragmented vision of child development and to promote interventions that combine cognitive teaching with emotional learning.

4. Practical and policy implications

In applied terms, the results suggest that **early cognitive stimulation programs** should be designed with a **holistic and interdisciplinary approach**, incorporating components of **socio-emotional education, family accompaniment, and teacher training**. The integration of these three levels allows for the creation of a coherent environment that reinforces the child's learning and emotional regulation.

It is also recommended that **education policymakers** strengthen teacher training in affective pedagogies and in the use of evidence-based cognitive stimulation tools (Miller et al., 2021). Similarly, early childhood care

programs should include **parental training modules** to improve affective communication, emotional regulation, and educational co-responsibility at home (González et al., 2024).

Table 1 summarizes the main practical implications derived from the study.

Table 1. Practical implications of the results

Action Level	Recommendation	Supporting Evidence
Familiar	Include parenting training workshops in early stimulation programs	González et al. (2024)
Pupil	Train teachers in emotional pedagogy and integrated cognitive stimulation strategies	Sluiter et al. (2025); López & García (2023)
Political/Institutional	Incorporating social-emotional development into early childhood policies	Hernández et al. (2023); Miller et al. (2021)

5. Limitations and recommendations for future research

Despite the methodological robustness, the study has some limitations. First, the sample was **non-probabilistic and localized in an urban context**, which could limit the generalizability of the results to other rural or culturally diverse populations. Second, although the longitudinal design allowed us to observe trends of change, biological or neurophysiological measurements that could provide more direct evidence on the brain mechanisms involved in cognitive-emotional coevolution were not incorporated (Nelson et al., 2020).

Future research could:

1. Implement **randomized experimental designs** with long-term follow-up.
2. Integrate **neuropsychological indicators** and **qualitative evaluations** of the family context.
3. To analyze the **mediating effects** of executive functions on the link between ECT and HSE (Gutiérrez et al., 2021).

These lines of research would allow us to deepen our understanding of how early cognitive experiences configure stable emotional and social networks during development.

6. General conclusion

In summary, the evidence presented shows that **early cognitive stimulation is a protective and enhancing factor of socio-emotional development**, whose impact is modulated by family and educational conditions. The multilevel approach used made it possible to capture the complexity of this phenomenon, integrating the individual, contextual and temporal dimensions of development.

Therefore, it is concluded that **early childhood policies and programs must transcend the traditional academic paradigm and be oriented towards a comprehensive education model**, where cognition and emotion are understood as inseparable dimensions of human growth (Bronfenbrenner & Morris, 2020; Sluiter et al., 2025). This systemic and evidence-based vision is the most promising way to promote a full, resilient and socially competent childhood.

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