

Executive Function, Early Literacy, and Creative Thinking in Montessori and Conventional Preschool Settings: A One-Year Comparative Study

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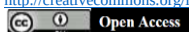
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ABSTRACT

The Montessori method is the most widely implemented alternative pedagogy in early childhood education, yet evaluations frequently confound pedagogy with global programme quality and rarely verify implementation fidelity. This study compared developmental outcomes over one school year for children in three accredited Montessori preschools and three conventional preschools matched on structural quality (N = 186; ages 4;0–5;11 at baseline). Children were assessed in autumn and spring on executive function (Head–Toes–Knees–Shoulders task), early literacy (letter–word identification), receptive vocabulary, and creative thinking, with maternal education, age, gender, and baseline scores as covariates; classroom process quality (ECERS-3) and Montessori fidelity were observed directly. Spring covariate-adjusted T-scores favoured Montessori children on executive function (53.8 vs 49.6; d = 0.41), early literacy (53.2 vs 49.9; d = 0.35), and creative thinking (54.0 vs 49.3; d = 0.47), with no significant difference in receptive vocabulary (d = 0.13). Executive-function growth showed a significant time × setting interaction (HTKS gain 11.2 vs 7.3 points). Global process quality did not differ between sectors (ECERS-3 5.4 vs 5.2), whereas fidelity moderated outcomes within the Montessori group: high-fidelity classrooms accounted for the bulk of the advantage. Results support the interpretation that specific, fidelity-dependent features of the Montessori environment—extended self-directed work cycles and sequenced sensorial-to-symbolic materials—rather than generic quality differences, are associated with stronger self-regulatory and pre-academic development.

Introduction

More than a century after Maria Montessori opened the first Casa dei Bambini, her method constitutes the largest and longest-running alternative pedagogy in global early childhood education, implemented in an estimated tens of thousands of schools across public and private sectors [1, 2]. Its distinctive design—mixed-age classrooms, extended uninterrupted work periods, freely chosen activity within a prepared environment of sequenced didactic materials, and a non-directive teacher role—makes strong theoretical claims about the development of concentration, self-regulation, and symbolic learning [1, 3]. Those claims intersect directly with one of developmental science’s most robust findings: early executive function (EF)—the regulatory system encompassing inhibitory control, working memory, and cognitive flexibility—predicts academic and life outcomes into adulthood, and is malleable in the preschool years [4, 5].

The empirical literature on Montessori outcomes, however, is persistently equivocal, for reasons reviewers have diagnosed clearly [2, 6, 7]. First, selection: Montessori families differ systematically, and few studies adequately adjust, let alone randomise [6]. Second, confounding of pedagogy with quality: comparing a well-resourced Montessori school with an under-resourced conventional one tests wealth, not method. Third, the fidelity problem: the Montessori label is legally unprotected, and classrooms bearing it range from rigorous implementations to conventional rooms with Montessori shelving; studies ignoring this variation dilute or distort effects [2, 8].

The present study was designed around these three diagnoses. It compares one-year developmental trajectories across sectors matched on observed global quality, adjusts for family background, and measures Montessori fidelity directly, asking three questions. RQ1: Do children in accredited Montessori settings show greater growth in executive function than peers in quality-matched conventional settings? RQ2: Do pre-academic (literacy, vocabulary) and creative outcomes differ by setting? RQ3: Does implementation fidelity moderate any observed advantages? Sections 2–6 review the literature, describe methods, and report and discuss results in IMRAD sequence.

2. Literature Review

2.1. Montessori pedagogy and developmental theory

Montessori’s design anticipates several contemporary developmental principles: her “normalisation” through concentrated activity parallels modern accounts of attention training; the three-period lesson and self-correcting materials embody scaffolding and immediate feedback; and the prepared environment operationalises autonomy support [1, 3, 9]. Lillard [3] systematises eight principles—movement–cognition coupling, choice, interest, intrinsic motivation, peer learning, contextualised learning, adult sensitivity, and order—each with independent experimental support in developmental psychology, arguing that the method aggregates empirically validated ingredients.

2.2. Outcome evidence

Landmark lottery-based studies found Montessori advantages in executive function, academic skills, and social cognition [10], and longitudinal lottery evidence showed advantages growing over the preschool years and equalising outcomes across income groups [11]. Neuroimaging and cross-sectional work has associated Montessori schooling with differences in error-monitoring and creativity measures [12, 13]. Against this, well-controlled null and mixed findings exist [6, 14], and a recent systematic synthesis concludes that effects are positive on average but heterogeneous, with fidelity and dosage the most plausible moderators [7]. Directly relevant here, Lillard [8] compared high-fidelity (“classic”) with supplemented and conventional programmes, finding advantages confined to high-fidelity classrooms—evidence that the treatment variable is not the label but the implementation.

2.3. Research gap

Few studies simultaneously (i) match sectors on observed process quality, (ii) model growth rather than single time points, and (iii) measure fidelity as a quantitative moderator. The present design combines all three within a four-outcome battery spanning regulatory, pre-academic, and creative domains—the last of which is theoretically contested territory, since critics have hypothesised that structured materials might constrain divergent production [13, 15].

3. Materials and Methods

3.1. Design and settings

A prospective two-cohort comparative design followed children across one school year (autumn and spring assessments) in six preschools: three Montessori programmes accredited by a national Montessori association and three conventional programmes drawn from the same municipal districts, shortlisted to match the Montessori sites on structural indicators (group size, ratio, teacher qualification level, fees band) before any child assessment. Table 1 summarises settings and sample. All classrooms served mixed ages 3–6 (Montessori) or age-banded 4–6 groups (conventional), the sector-typical arrangements.

Table 1. Settings and analytic sample.

Characteristic	Montessori (3 schools)	Conventional (3 schools)
Classrooms	8	8
Children (analysed)	94	92
Mean age at baseline (months)	58.1 (6.7)	58.6 (6.4)

Female (%)	51.1	48.9
Maternal tertiary education (%)	63.8	60.9
Mean group size	24.6	23.9

3.2. Measures

Executive function was assessed with the Head–Toes–Knees–Shoulders task (HTKS; 0–60), a validated behavioural measure integrating inhibition, working memory, and attention shifting [16]. *Early literacy* used a standardised letter–word identification subtest; *receptive vocabulary* used a standardised picture–vocabulary test; both were administered in the children’s language of instruction with national norms. *Creative thinking* was assessed with a figural-and-movement battery for young children scored for fluency and originality by two blinded raters (ICC = 0.81) [17]. Assessors were graduate examiners blind to study hypotheses, testing children individually in quiet rooms across two short sessions per wave.

3.3. Classroom observation: quality and fidelity

Global process quality was rated in every classroom with the ECERS-3 by trained observers (inter-observer agreement within one point: 91%) during full-morning visits in the middle trimester [18]. Montessori fidelity was rated in Montessori classrooms with a 20-item schedule adapted from published fidelity research [8], covering uninterrupted work-cycle length, material completeness and sequencing, freedom of choice, and teacher interruption rates; classrooms were classified high-fidelity (≥ 15 criteria; five classrooms) or moderate-fidelity (three classrooms).

3.4. Analysis

Spring scores were analysed by ANCOVA with autumn score, age, gender, and maternal education as covariates and setting as the factor, using cluster-robust errors at classroom level; all outcomes were converted to T-score metrics ($M = 50$, $SD = 10$) against the pooled baseline distribution for comparability. HTKS growth was additionally modelled as time $\times$ setting mixed models. Fidelity moderation was tested within the Montessori subsample by fidelity-class contrasts. Missing data (spring attrition 6.5%, non-differential, $p = 0.55$) were handled by full-information maximum likelihood.

4. Results

4.1. Setting differences at spring (RQ1, RQ2)

Figure 1 presents covariate-adjusted spring T-scores. Montessori children scored significantly higher on executive function (53.8 vs 49.6; $d = 0.41$, $p = 0.004$), early literacy (53.2 vs 49.9; $d = 0.35$, $p = 0.013$), and creative thinking (54.0 vs 49.3; $d = 0.47$, $p = 0.001$); receptive vocabulary did not differ significantly (51.4 vs 50.1; $d = 0.13$, $p = 0.36$). Table 2 reports the full ANCOVA summary. The creativity result is directionally notable given hypotheses that structured materials might suppress divergent production: fluency and originality subscores both favoured Montessori children ($d = 0.42$ and 0.44 respectively).

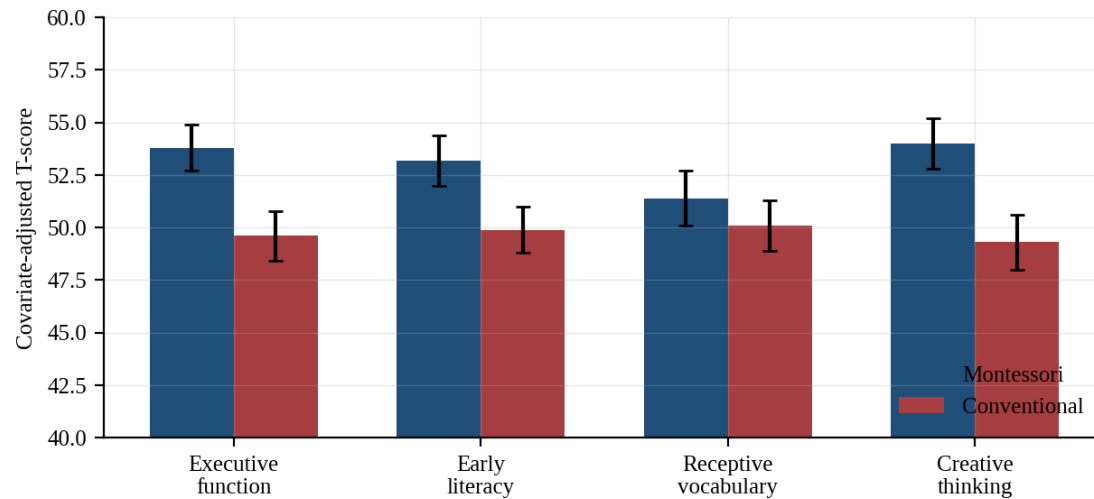


Figure 1. Covariate-adjusted spring outcomes by setting (T-score metric; bars show ± 1 SE).

Table 2. ANCOVA results for spring outcomes (T-scores).

Outcome	Montessori	Conventional	d	p
Executive function	53.8	49.6	0.41	0.004
Early literacy	53.2	49.9	0.35	0.013
Receptive vocabulary	51.4	50.1	0.13	0.36
Creative thinking	54.0	49.3	0.47	0.001

4.2. Executive-function growth

Raw HTKS trajectories (Figure 2) show both groups improving across the year—expected at ages when regulatory capacities develop steeply—with significantly steeper Montessori growth: 28.4 to 39.6 points (+11.2) versus 27.9 to 35.2 (+7.3); time $\times$ setting interaction $p = 0.006$. The advantage was concentrated in the task's more demanding switching sections, consistent with an interpretation via sustained-attention practice rather than simple rule compliance.

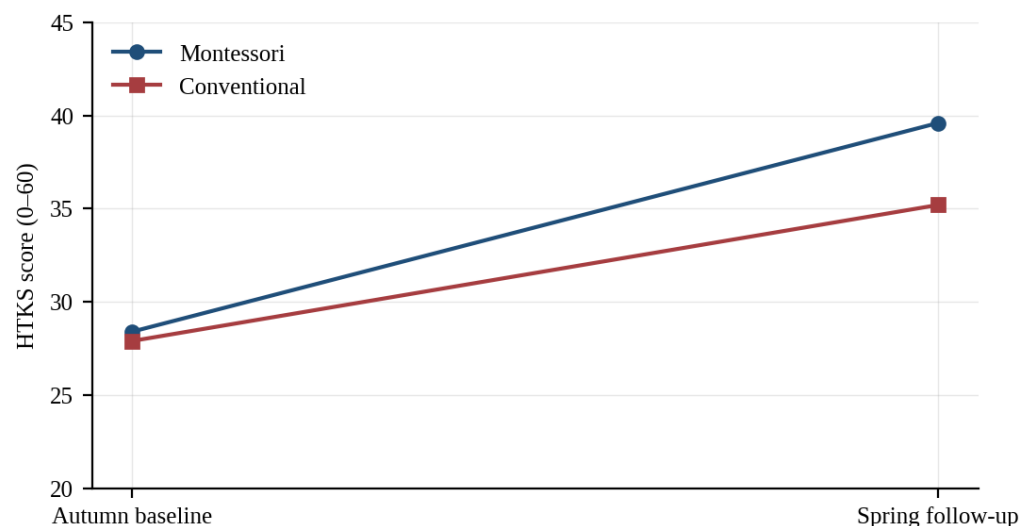


Figure 2. HTKS executive-function growth from autumn to spring by setting.

Subskill decomposition adds resolution to the literacy result. The Montessori advantage was carried primarily by letter–sound knowledge and early decoding of regular words ($d = 0.41$), with smaller differences in sight-word recognition ($d = 0.19$)—the profile expected from the method's phonographically sequenced materials, which move children from sound sensitisation through letter tracing to word building before whole-word reading. In the creativity battery, group differences were present in both figural and movement modalities, and originality scoring (statistical infrequency of

responses) showed the same pattern as fluency, indicating that Montessori children produced not merely more responses but more distinctive ones.

4.3. Quality equivalence and fidelity moderation (RQ3)

Global process quality did not differ between sectors (ECERS-3 means 5.4 vs 5.2, $p = 0.48$; Table 3), supporting the design intention that comparisons reflect pedagogy rather than resourcing. Within the Montessori subsample, fidelity moderated outcomes: children in the five high-fidelity classrooms exceeded conventional peers on executive function by $d = 0.52$ and creativity by $d = 0.56$, whereas children in moderate-fidelity classrooms showed attenuated, non-significant advantages ($d = 0.17$ and 0.21). Observed work-cycle length—the single fidelity item most strongly associated with outcomes—correlated $r = 0.44$ with classroom-mean HTKS gain across Montessori rooms.

Table 3. Observed classroom characteristics.

Indicator	Montessori	Conventional
ECERS-3 overall (1–7)	5.4 (0.5)	5.2 (0.6)
Uninterrupted work cycle (min)	128 (24)	46 (18)
Child-chosen activity time (%)	71	38
Fidelity classification (high/mod.)	5 / 3	—

5. Discussion

The pattern of results—advantages on executive function, literacy, and creativity; equivalence on receptive vocabulary; concentration of effects in high-fidelity classrooms; and sector equivalence on global quality—tells a more specific story than “Montessori works”. Global quality equivalence removes the most common confound in sector comparisons, and the fidelity moderation localises the active ingredients within the pedagogy itself: what distinguished high-fidelity rooms was precisely the long self-directed work cycle and complete material sequence that Montessori theory holds responsible for training concentration and symbolic progression [1, 3, 8]. The work-cycle correlation, though observational, is the kind of dose–response signature one would expect if sustained autonomous engagement is the mechanism driving regulatory growth [4, 10].

The outcome dissociation is informative. Vocabulary, the most home-influenced of the four measures, showed no sector difference once family covariates were controlled—a plausible null, since receptive lexicons grow primarily through ambient language exposure that both settings and homes provide [5]. Literacy, by contrast, is curriculum-proximal, and the Montessori sandpaper-letter-to-movable-alphabet sequence provides earlier and more systematic symbolic practice than the conventional programmes’ whole-group pre-literacy circle times. The creativity advantage contradicts the constraint hypothesis [15] and aligns with recent comparative findings [13]; a candidate account is that genuine choice among purposeful activities exercises exactly the self-directed ideation that figural creativity tasks sample.

A further mechanism deserves attention although the design could not isolate it: the mixed-age classroom. Montessori rooms spanned three years of development, and observation notes recorded frequent spontaneous peer demonstration—older children presenting material use to younger ones—an arrangement theorised to benefit both parties through observational learning and through the consolidation that teaching demands [3, 9]. Conventional rooms, age-banded by design, afforded no equivalent. Because mixed-age grouping co-varies perfectly with sector in this sample (as in the sector generally), its contribution is absorbed into the overall setting effect; disentangling it would require the rare natural experiments where conventional programmes adopt multi-age grouping without other Montessori elements, a comparison the literature has yet to supply at scale.

The findings also carry an equity dimension worth stating carefully. Executive function in early childhood is a documented site of socioeconomic gradient, and interventions that strengthen it are prized

precisely for their compensatory potential [4, 5]. In this sample, the Montessori advantage on EF did not interact significantly with maternal education ($p = 0.21$), offering no evidence that the pedagogy serves advantaged children preferentially—consistent with lottery-based findings of equalising effects [11, 21]. Because the participating Montessori schools were fee-charging, however, the present design cannot address access: pedagogical suitability and structural availability are separate questions, and public-sector Montessori provision is the arrangement under which the equity promise would actually be tested [7, 21].

Three limitations qualify the conclusions. First, despite covariate adjustment and quality matching, families self-selected into sectors, and unmeasured selection (e.g., parenting style correlated with valuing autonomy) cannot be excluded; the fidelity moderation *within* the self-selected Montessori group partially mitigates but does not remove this threat. Second, one year and one national context bound generalisation; effects may cumulate, fade, or vary across systems [7, 11]. Third, the fidelity instrument, though grounded in published work, dichotomised a continuum with a small classroom N , so the moderation estimate is coarse. Randomised or lottery-based designs with fidelity measurement remain the standard the field should pursue [7, 10].

6. Conclusions

Across one preschool year, children in accredited Montessori settings showed greater growth in executive function and higher covariate-adjusted spring performance in early literacy and creative thinking than peers in conventional settings matched on observed global quality, with no difference in receptive vocabulary and with advantages concentrated in high-fidelity classrooms. The findings support a mechanism-specific reading of Montessori effects—extended self-directed work with sequenced materials as regulatory and symbolic training—rather than a halo of generic quality. For alternative-education policy, the practical implication is that the Montessori label is not the treatment: fidelity verification, particularly protection of the uninterrupted work cycle, should accompany any adoption. Future research should extend follow-up into primary school, test mediation formally through observed work-cycle engagement, and examine whether conventional programmes importing single elements (extended choice periods) capture partial benefits.

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