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Stimulating and Developmentally Supportive Practices in Early Childhood Education: A Multiple-Case Study

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Abstract: This study explored possible associations between educational interventions implemented in an environment based on Montessori principles and select cognitive, perceptual-motor, and behavioral manifestations in early childhood. A multiple-case study design was employed, involving four children aged 5 to 6 years. Data collection included pretest and posttest assessment using Controlled Drawing Observation and the T–32 Drawing Copy Test, systematic observation, video recordings, and analysis of children's work products. In between assessments, the participants attended twelve educational intervention sessions designed according to Montessori principles. Findings indicated qualitative changes in attention to detail, organization of drawings, accuracy of reproducing visual models, and selected aspects of visuomotor coordination. Changes were also observed in autonomy, organization of work, use of error control, and reduced reliance on adult reassurance. Some participants continued to experience difficulties in processing more complex instructions. Given the exploratory nature of the study and the small sample size, the findings should not be interpreted as evidence of the effectiveness of Montessori education but rather as indications of possible relationships between educational environments, learning processes, and child development.

In this study, analysis is based on the assumption that not only the educational environment, but also the teacher's educational approach plays a significant role in the learning process (Imai, 2017; Montessori, 2012; Piaget & Inhelder, 2014). Previous research further suggests Montessori pedagogy can foster children's autonomy, concentration, active engagement in learning, and respect for individual development (Denervaud & Slováček, 2025). Therefore, Montessori pedagogy is conceptualized in this study as an educational approach through which learning processes and conditions that may support child development can be examined.

The article's theoretical framework is grounded in the assumption that language acquisition is part of broader cognitive processes and is dually shaped by biological and social factors (Fernández & Smith

Cairns, 2014; Slančová, 2018; Vužňáková, 2015, 2018a, 2018b, 2020a). Language is perceived not only as a communication tool, but also as a means of organizing thought and understanding the world (Vaňková, 2007; Vaňková et al., 2005; Vužňáková et al., 2025). Building on the theoretical framework of Vužňáková (2013), the article assumes an interconnected relationship between cognitive development and language acquisition. Language development, attention, working memory, categorization, executive functions, and perceptual-motor processes are therefore understood as mutually interconnected domains that contribute to organization of the learning process.

The main purpose of the study was to explore possible associations between educational interventions based on Montessori principles and changes in selected cognitive, executive, and perceptual-motor functions, as well as in behavioral manifestations related to work organization, concentration, and independence in preschool-aged children. Concurrently, the study aimed to identify characteristics of the educational environment that may support children's learning, concentration, and independence.

The research question focused on what changes in selected developmental areas could be observed in children after completing educational interventions implemented in an environment guided by Montessori principles—specifically in the domains of cognitive functioning, executive and perceptual-motor functions, and behavioral manifestations related to concentration, independence, and work organization.

The research was designed as an exploratory, qualitative inquiry, using a multiple-case study design. Rather than seeking to generalize the findings to a broader population, the study aimed to gain a deeper understanding of possible associations between educational environment, learning processes, and individual development in preschool children. Importantly, the study was not intended to advocate for a specific educational method, but rather to explore conditions and mechanisms that may support children's learning and development (Gaujard & Denervaud, 2023).

Method

Between 2024 and 2025, I conducted a multiple-case study involving four individual cases of preschool-aged children. The aim of the study was to explore possible changes associated with educational interventions based on Montessori principles. The interventions were designed so the children's work respected use of self-correcting didactic materials, which were developed on the basis of a pilot study carried out as part of broader research with a different group of children.

During preparation, I drew upon the possibilities of using self-correcting materials that stimulate language development and insights into Slovak language acquisition, freedom of choice of activity and uninterrupted work cycles (children were allowed to work according to their personal choice and at their own pace), independent work of children with available teacher support, and creation of individualized workspaces (as the the sole researcher–observer, I was also available to the children as a pedagogue and intervened as needed or upon the children's request). I as the teacher-administrator introduced the materials, and afterward the children engaged in independent work.

I understand these Montessori-based principles as components of an educational environment that can foster child autonomy, active learning, concentration, and respect for individual developmental needs. The Montessori principles created conditions enabling work at one's own pace, repetition of activities, self-correction, and sensory exploration through manipulation of didactic materials.

The research sample consisted of four children aged 5 to 6 years from a single kindergarten classroom in the second largest city in Slovakia (see Table 1). Participants were selected based on availability and recommendations from classroom teachers. Children whose legal guardians provided informed consent for participation in the research were included in the study. The study was conducted in accordance with ethical principles of educational research. I informed legal guardians about the study's objectives, course of interventions, data collection and processing procedures, and the voluntary nature of participation. Participant anonymity was preserved.

All children exhibited typical development and had no diagnosed developmental or health problems. They came from similar middle-class socioeconomic backgrounds in Slovakia. All attended the same kindergarten classroom, had the same teachers, and prior to entering the study, had experienced primarily a traditionally organized educational environment. Prior to the intervention, the educational environment corresponded to the standard, traditionally oriented model of preschool education in Slovakia. In this context, traditional education is understood as time-limited instruction within an age-homogeneous group of children—instruction is teacher-led, planned in

Table 1
Characteristics of Participants

Criterion	Child 1	Child 2	Child 3	Child 4
Average Age	6 years 2 months	6 years 2 months	5 years 11 months	5 years 7 months
Family Background	Second child (sibling aged 15 years), mother with secondary education	Second child (sibling aged 9 years), mother with Master's degree, father with secondary education	First child (sibling aged 2.5 years), both parents with Master's degrees	Second child (sibling aged 12.5 years), both parents with Master's degrees
Kindergarten Attendance	From 3 years of age	From 2 years of age	From 3 years of age	From 3.5 years of age

Note. Values represent the average age of children at pretest and posttest.

advance according to themes, and predominantly externally motivated.

The daily routine in the kindergarten includes organizational forms in which children typically engage simultaneously under the teacher's direction. These primarily involve health exercises and educational activities reflecting the national curriculum:

> Health exercise is carried out every day at a specific time.... It belongs to pre-planned activities.... Educational activities are activities related to the mediation of planned educational content.... They can be implemented as individual, group, or frontal activities of children (National Institute for Education, 2016, pp. 8–9).

Note that frontal, and occasionally group forms, predominated in the kindergarten where the research was conducted. The typical daily kindergarten schedule also includes children's self-selected games and activities, as well as outdoor time. During these periods, children have space for independent choice of toys and self-organization of play according to personal preferences; however, these still occur within time constraints determined by the teacher and daily schedule.

Before research implementation, the studied kindergarten did not possess specialized Montessori materials and had not implemented Montessori-inspired environmental organization. Likewise, teaching staff had not completed professional training or certified courses focused on Montessori pedagogy.

The study was designed as an exploratory qualitative inquiry, using a multiple-case study design. The goal was not to generalize findings to a broader population of young children, but rather to gain a deeper understanding of possible relationships between the nature of the educational environment, learning processes, and individual development in preschool children. This design allowed for more detailed observation of individual cases, children's working styles, and manifestations of learning in specific contexts.

Pretest assessments took place between September 2024 and November 2024, whereas posttest assessments were conducted from March 2025 to April 2025. Between these periods, the children participated in 12 intervention sessions held from December 2024 to March 2025.

Data collection procedures included direct and systematic observations of the children during testing and intervention sessions, video recordings of selected activities, use of standardized tools for individual testing of children, analysis of children's work products—particularly drawings created within the administered tests—and a demographic questionnaire (Miňová, 2023). Observational data and other available records were gathered in relation to the study's objectives and the monitored domains of learning and development.

Data obtained from pretest and posttest assessments were analyzed alongside video recordings, observational notes, and children's work products in relation to the study's objectives. The analysis was based on comparing data collected prior to and after completion of the interventions, as well as on qualitative interpretation of direct observations, video recordings, and children's performances captured in drawing products. The analysis involved tracking changes in task execution, behavioral manifestations, work organization, concentration, and other manifestations relevant to the study's objectives.

I independently carried out observation, test administration, and implementation of the interventions, simultaneously serving as researcher, observer, evaluator,

Table 2
Instructions for the Child: Controlled Drawing Observation

#	Instructions for the Child
Introduction	*"We are going to draw some pictures. You will draw only what I tell you."*
1.	Draw a ball in the middle of the paper.
2.	Draw a line from the ball to one of the corners of the paper.
3.	Draw lines from the ball to the other corners of the paper.
4.	Count how many sections (boxes) you have on your paper.
5.	Draw a line from the ball to the side of the paper.
6.	Draw the remaining lines from the ball to the other sides of the paper.
7.	Let's count again how many sections/boxes we have.
8.	Pick a box/section to start drawing in. Draw three lines that are not the same length.
9.	Draw three triangles so that the middle one is the smallest.
10.	Draw four circles so that two of them are the same size. Now place an X inside the circles that are the same size.
11.	Now draw four squares in a row next to each other so that the last one is the largest, and mark it with an X.
Transition	*"Alright, we are done with lines, triangles, and circles now, and we'll start drawing something completely different."*
12.	Draw a tree—an apple tree with three apples on it and five apples on the ground under the tree.
13.	Put your pencil down now and listen carefully. Draw a house with a door, three windows, and a pointed roof. Draw a chimney with smoke on the roof. Next to the house is a tree, and above the tree is the sun.
14.	Draw a human figure.
15.	Draw a cat (it can also be a dog).

and intervention facilitator. This multiplied role of the researcher represents one limitation of the study, as direct involvement in implementing the interventions could have influenced the observation process and data interpretation. However, in qualitative research, the researcher is not entirely detached from the research process, but is an integral part of it, and their position may influence both data collection and interpretation. Therefore, during research implementation and data analysis, I strove for the most systematic and transparent approach possible, primarily through triangulation of multiple data sources, including direct observations, video recordings, individual testing results, and children's work products.

Individual testing methods included Controlled Drawing Observation and the T–32 Drawing Copy Test. Both instruments are standardized diagnostic tools.

Controlled Drawing Observation (see Table 2), developed by Krogh, is designed to assess school readiness. In Slovakia, the test was adapted by Gajdošová and Herényiová (1996). The instrument provides information on working speed, work style, motor coordination, visual abilities, memory functioning, verbal comprehension of concepts, mathematical understanding, and overall developmental level. For the test, the child is given a blank sheet of white A3 paper and a pencil. The administrator provides instructions according to the manual, and the child completes the tasks by drawing. For the purposes of this study, the test was administered individually to each student. During evaluation, I monitored performance on the worksheet (final product) as well as the children's behavioral manifestations during testing (task completion, concentration, motor calm/restlessness). Results were interpreted qualitatively, with particular emphasis on changes between pretest and posttest evaluations.

The T–32 Drawing Copy Test is used to assess neurological functioning in children, particularly in relation to perceptual-motor difficulties and potential mild cognitive deficits. The test provides information on motor functioning, visual perception, and visuomotor coordination. The instrument, developed by Matějček and Vágnerová (1992), was administered individually and evaluated according to the manual. For this test, the administrator presents the child with 12 A5-format cards featuring various geometric and graphic models one by one. The child's task is to copy each presented model onto paper. In this study, all models were administered and evaluated. In the following text, I present primarily those models in which qualitative changes were recorded

between the pretest and posttest evaluations. Models that did not show any significant qualitative change are not discussed.

Procedure

To facilitate interpretation of findings, I briefly describe activities implemented during the intervention sessions. These observations were part of a broader research project aimed at exploring possibilities of supporting language development through Montessori principles and educational approaches that respect children's developmental needs.

Prior to commencement of the interventions, the children completed a pretest evaluation, and information regarding their developmental and behavioral characteristics was collected. Data collection included Controlled Drawing Observation, the T–32 Drawing Copy Test, speech and language assessment using verbal-visual and verbal-manipulative instruments, teachers' and parents' or legal guardians' evaluations of children's behavioral manifestations, a demographic questionnaire, and direct observation of the children.

Subsequently, the children participated in a 12-session 60-minute intervention protocol conducted in the kindergarten classroom. The interventions were carried out with four children aged 5–6 years. The first six sessions (December 2024–January 2025) focused on becoming familiar with the letters of the Slovak alphabet, and developing initial reading and writing skills. The children worked primarily with Sandpaper Letters, the Movable Alphabet, three-part cards, and activities aimed at identifying initial sounds. Partial mastery of the alphabet established a prerequisite for subsequent work with original didactic materials.

The following six sessions (February 2025–March 2025) were dedicated to working with four original didactic materials developed according to Montessori principles. The materials were created based on data obtained during the pilot phase, principles of Montessori didactic materials, and research findings on child speech and language development (Drozdová, 2020a, 2020b; Liptáková & Vužňáková, 2009; Vužňáková, 2020a, 2020b), as well as insights from cognitive linguistics (Pacovská et al., 2021; Vužňáková, 2015). During the interventions, the children worked with didactic materials designed in accordance with Montessori principles and developmental linguistics insights related to the Slovak language. The materials focused on developing letter recognition, reading, and writing (Slováček & Miňová, 2017), as well as acquiring selected linguistic and communicative phenomena specific to the Slovak language. The activities were intentionally restricted to the domain of language and communication. Work with language materials and speech stimulation in this research served primarily as a content framework for the educational interventions, creating a context in which learning processes and selected manifestations of child development could be observed. The interventions focused primarily on the following:

- diminutives and naming animal offspring
- vocabulary development and lexical categorization
- adjective degree comparison
- understanding prefix meanings and using prefixed verbs

During the educational interventions, the children worked with four original didactic materials designed in accordance with the principles of Montessori (1948): isolation of difficulty, control of error, aesthetics, activity, and limits. In terms of construction, the materials consisted of a system of base frames (templates) and specially shaped inset boards of various sizes and profiles that respected developmental peculiarities of child perception (e.g., differentiating between the meanings of "small" and "young" via board dimensions, or differentiating categorization levels through element shapes). In accordance with Montessori pedagogy, the administrator introduced each material modally. In subsequent sessions, the children worked completely independently and freely according to their personal choices. The actual work with the materials took place through structured placement, comparison, and categorization of visual picture and text stimuli, with children having the opportunity for autonomous self-correction using color-coded dots on the backs of the boards. Findings presented in this study are part of a broader research project focused on language acquisition in preschool age (Slováček, 2025).

Sessions generally followed a two-phase structure: (1) The initial 15 minutes were dedicated to presenting new material, with the administrator demonstrating its use and introducing relevant linguistic phenomena. (2) The following 45 minutes allowed children to work independently with available materials of their choice and at their own pace. While working, they selected, carried, inserted, matched, and paired materials, primarily engaging vision, touch, and movement. They worked in individualized workspaces and could repeatedly return to specific activities. In addition to the newly presented

material, selected materials from previous sessions were also available, with the selection being updated periodically. Two sessions were conducted without presentation of new material, focusing on repetition and independent work with already familiar materials. Given the principle of free choice, the amount of work completed with individual materials was not identical for all children.

It is important to emphasize that tasks required in Controlled Drawing Observation and the T–32 Drawing Copy Test were not explicitly practiced during the interventions. Interventions therefore did not target elements such as following instructions, drawing, paper-and-pencil tasks, quantitative understanding, or other activities typically associated with standardized testing situations. The children's performance on these tests was thus not a direct result of practicing specific test-related tasks.

Following completion of the interventions, the children were reevaluated using the same instruments as at the beginning of the study. During the posttest evaluation of Controlled Drawing Observation and the T–32 Drawing Copy Test, qualitative changes in children's performance were monitored in comparison to the pretest evaluation. Interpretation of these changes was also grounded in observations of the children during testing and intervention sessions. Special attention was paid to task execution style, work organization, concentration, independence, responses to instructions, and other behavioral manifestations relevant to the study's objectives.

This structured procedure makes it possible to distinguish the content of the language interventions from the domains monitored through subsequent testing. Changes recorded in the tests are therefore interpreted as exploratory findings within individual cases, rather than unambiguous proof of effectiveness of interventions or of Montessori pedagogy.

Results

As noted in the preceding section, certain changes in performance and execution of administered tasks were recorded in all four participants over the course of the monitored period, although their nature and extent varied among individual participants. Given the qualitative nature of the study and its small sample size, I interpret these changes as individually observed manifestations rather than evidence of a causal effect of the interventions. Alongside changes in performance on test tasks, I also observed changes in independence, concentration, work organization, and the way participants approached errors and task completion.

Controlled Drawing Observation

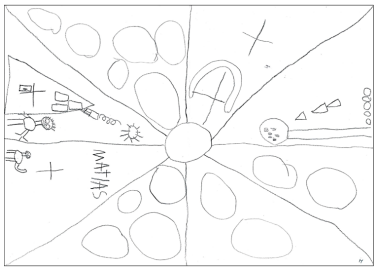
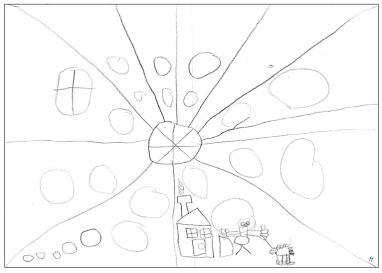
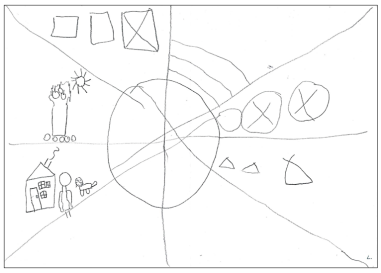
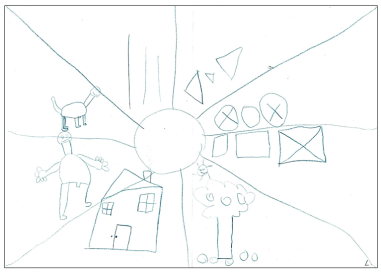
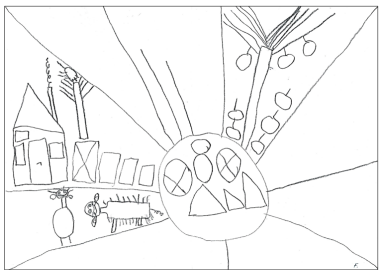
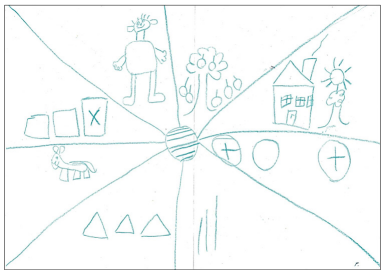
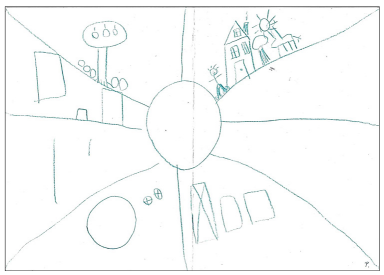
In the analysis of performance on Controlled Drawing Observation (see Table 3), I focused primarily on understanding and carrying out instructions, spatial orientation, perception and differentiation of details, numerical and geometric concepts, drawing organization, and behavioral manifestations during testing.

For Participant 1, an active and calm manner of working was observed during initial and final diagnostics. During the initial assessment, however, the participant repeatedly sought reassurance from the administrator, whereas during the final assessment, this need did not manifest as the participant worked independently. In both assessments, the participant demonstrated understanding of basic spatial concepts—such as center, corner, and side of the paper—as well as numerical concepts. The final assessment showed no definitive change in overall performance level; however, qualitative changes were observable in execution of certain drawing tasks and in the drawing process in general. Instruction was executed more precisely in drawing a house with a pointed roof and placing a ball in the center of the sheet. The drawings of a human figure and an animal exhibited more details, such as prominently drawn fingers and a more detailed depiction of the animal, including fur and the ends of limbs. Difficulties persisted in tasks requiring differentiation of geometric shapes, size relationships, or retaining longer instructions. These areas were not subject to specific practice during the interventions.

For Participant 2, an active, calm, and independent manner of working was observed during both diagnostic assessments, though initially with a tendency toward an overly rapid pace. The participant mastered discriminating the center, corners, and sides of the paper, knew basic geometric shapes, and was able to create groups with the requested number of elements. Difficulties arose mainly with longer instructions and tasks requiring simultaneous application of multiple criteria—such as quantity and size—limited by developing working memory. During the final assessment, higher-quality execution of certain tasks and greater attention to detail were observed. Direct observation of drawing and copying revealed a marked reduction in impulsivity, as Participant 2 slowed her working pace, focused more on the visual model, and centered her attention on detail. For instance, fingers appeared on the human figure, animal limbs were

Table 3

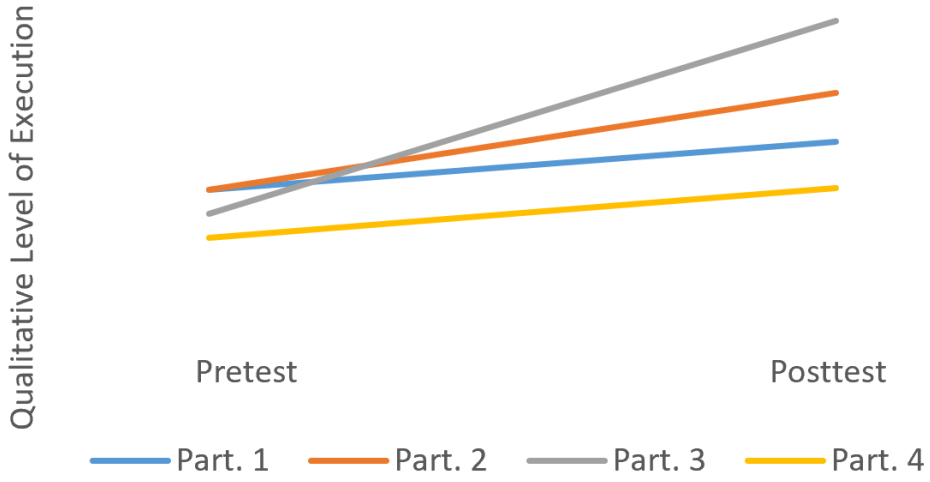
Controlled Drawing Observation

Participant	Pretest	Posttest
P1		
P2		
P3		
P4		

depicted in greater detail, and a chimney was added to the house. In the task requiring ordering of three triangles by size, the participant correctly placed the smallest triangle in the middle. However, difficulties in processing longer information containing multiple conditions continued to persist. In this case, the observed changes cannot be interpreted as a general improvement in understanding complex instructions.

For Participant 3, an active, calm, and independent manner of working was observed during the initial assessment. The participant mastered basic spatial and geometric concepts, numerical concepts, and most of the simpler drawing tasks. However, in some initial tasks, he was unable to fully observe all conditions of the assignment: hands and a visible torso were missing from the drawing of a human figure, required sizes were not correctly arranged in the square size task, and the participant failed to distribute individual subtest tasks into designated fields around the central ball. During the final assessment, a significant qualitative change

Figure 1.
Individual Trajectories of Change Between Pretest and Posttest



occurred. The test was executed in a more organized manner, and Participant 3 precisely partitioned individual assignments into separate spaces around the ball. A qualitative change was also observable in the detail execution—for example, placement and hatching and filling of the ball, house details (windows), and the drawing of animals. The drawing of a tree underwent an unequivocal transformation, acquiring the characteristic shape of a deciduous tree the participant had encountered in the intervention didactic material. In the task requiring arrangement of squares by size, the requirement was fulfilled more accurately in the final assessment (the last square was the largest). However, as with other participants, deviations occurred in adhering to the exact number of requested geometric shapes.

For Participant 4, an active, independent, and concentrated manner of working was observed during the initial assessment, accompanied by a strong tendency to verbally comment on everything. The participant mastered basic spatial concepts (drawing lines to corners and sides of the paper based on heard prepositions), numerical concepts, and size and geometric shape differentiation. The human figure drawing was simpler during the initial assessment. Following the interventions, a qualitative change was observed in overall execution of the test. Drawings appeared more refined, and the participant demonstrated a greater understanding of the required tasks. However, deviations in the exact number of requested geometric shapes continued to appear (drawing three elements instead of four). In the square arrangement task, a difference in the opposite direction was recorded: During the initial assessment the participant correctly marked the largest square last according to the instructions, but during the final assessment drew the largest square first. This case illustrates individual variability of performance and underscores the need to interpret with caution changes between individual measurements.

Across the individual cases, the most prominent qualitative change was observed in processing detail. Changes were noted in drawings of the human figure, animals, house, tree, ball, and other elements. However, difficulties with longer or multilevel instructions, and with precisely capturing the required number of elements, persisted in some participants. The observed changes therefore did not represent a uniform shift across all monitored areas.

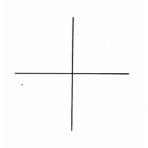
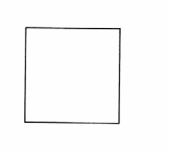
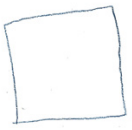
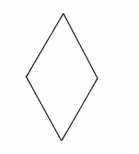
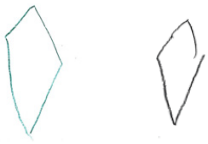
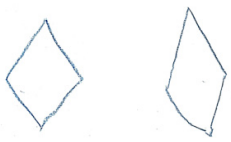
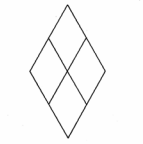
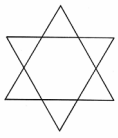
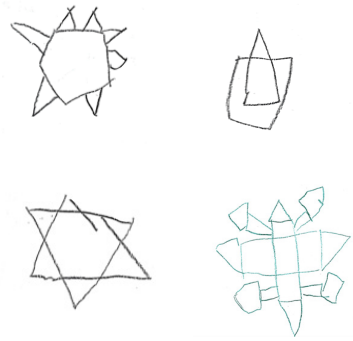
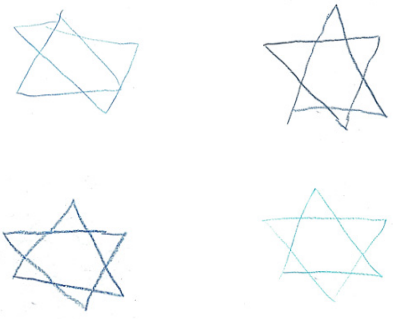
T–32 Drawing Copy Test

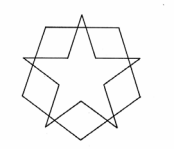
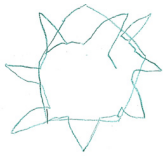
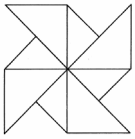
In the T–32 Drawing Copy Test, I focused primarily on the accuracy of copying the model, capturing its individual elements, spatial organization, visuomotor coordination, and the qualitative level of the drawings. Graphical representations are used to present the direction and nature of individual change between the pretest and posttest (see Figure 1). Individual lines represent developmental trajectories of individual participants. This form of representation makes it possible to track individual progress while simultaneously highlighting differences in developmental trajectories among participants.

Overall performance metrics and progress across assessment stages are detailed in Table 4. For Participant

Table 4.

T–32 Drawing Copy Test

Target Image	Pretest	Posttest
		
		
		
		
		

Target Image	Pretest	Posttest
	 	 
		

1, qualitative changes were manifested primarily in more complex shapes, such as the six-pointed star and the pinwheel, which were reproduced more accurately and with a greater number of captured details during the final assessment.

For Participant 2, changes were observable even in simpler items, such as the cross, in which the arms were approximately equal in length during the final assessment. In other items, a change in the quality of reproduction was evident, with a more pronounced difference observed in the six-pointed star and the five-pointed star in a pentagon. These drawings were more detailed during the final assessment and appeared graphically more refined compared to the initial assessment, reflecting the ability to slow down impulsive movements and focus on the visual model.

For Participant 3, qualitative changes were more pronounced in the rhombus, the rhombus with a cross, the six-pointed star, and the five-pointed star in a pentagon. The final drawings exhibited a more precise capture of the visual model, better representation of its individual parts, self-correction of lines, joining of angles, and a more detailed graphical execution.

For Participant 4, changes were observed in the square, rhombus, and six-pointed star, which were reproduced with greater precision and detail during the final assessment.

The qualitative analysis of the T–32 Drawing Copy Test thus suggests that changes did not appear uniformly across all items, but were most prominent in more complex figures requiring capture of multiple interrelated elements. Across cases, greater accuracy, detail, and organization of reproduction appeared repeatedly in final assessments. Given the nature of the research, however, I interpret these observations as individual qualitative changes rather than evidence of a general improvement in visuomotor skills.

Observed changes in processing detail were also interesting, given the nature of the intervention materials. Detail represented one component of working with language material, such as in lexical categorization, prefixed verbs, naming young animals, and forming diminutives. It is therefore possible to consider that systematic work with the materials created opportunities to pay attention to individual characteristics and differences between objects. However, given the study design, such an explanation cannot be considered a proven mechanism of observed changes.

Changes in Behavior, Independence, and Work Organization

Alongside results of the standardized assessments, changes in independence, work organization, the need for adult support, and the approach to error were observed during intervention sessions. Individual participants varied in these areas as well.

For Participant 1, the principle of error control and self-regulatory processes manifested very distinctly. During the fourth session, while working with prefixed verbs, the participant noticed an incorrect match after turning a card over, based on the control dot. Gradually, he internalized this method of checking to such an extent

that he even cautioned another child not to rely right away on the control dots, but to first think independently. When working with Sandpaper Letters, he independently identified a limitation of the material, noting that he could not spell all words using a single-set alphabet. Upon completing the task, he spontaneously expressed verbal satisfaction with his performance ("I am clever"). Over time, reduced need to seek contact with adults or other children was observed, and his activity assumed the integrated form of a structured work cycle: working with material → checking → returning material to its initial state → placing material back in its designated spot.

For Participant 2, a similar trajectory was observed regarding use of self-corrective material and development of internal autonomy. Early on in the interventions, when working with the alphabet, she used control markers directly during task completion. Following guidance, she transitioned to checking only after completing the work (initially using the picture). Gradually, she mastered fully independent verification of the results, and after finishing an activity, she spontaneously expressed quiet satisfaction ("yes") and without prompting put the material away in its designated spot. She also fully mastered working on the rug as her dedicated workspace. Her legal guardian's observations pointed to longer task persistence, improved ability to complete initiated tasks, and greater independence during play and activities without adult supervision.

For Participant 3, a recurring need for adult reassurance and questions regarding correctness of the activity being performed ("Am I doing it right?"), along with a frequent need for praise, were observed early on in the interventions. Over the course of the interventions, this pattern of work changed substantially: The participant began to fully utilize available self-corrective mechanisms of the materials, independently identified incorrect solutions, and made corrections autonomously without requiring external validation from an adult. Toward the end of the course of interventions, he worked independently, and his work followed the same structured work scheme as that of Participant 1: working with material → checking → returning material to its initial state → placing material back in its designated spot. Parents' and teachers' evaluations simultaneously pointed to a shift toward personal autonomy and reduced need to seek adult contact.

For Participant 4, independence during work and quick adaptation to working on the rug as a defined work area were evident from the start. However, a characteristic feature was frequent verbal commentary on the situation, increased interest in others, and strong verbal output that required guidance. Although the participant quickly mastered the principle of working on the rug and worked independently toward the end of the course of interventions, the ability to sustain attention and persist with a single activity remained less stable. Unlike the other participants, he did not fully internalize the principle of completing the entire work cycle—more frequently leaving work incomplete, putting the material away, and not resuming. Nevertheless, teachers' evaluations indicated shifts toward higher independence and reduced need for verbal reassurance during play or activity.

Thus, across cases, common yet not entirely uniform tendencies emerged in this area. The most prominent repeating patterns were gradual adoption of self-corrective materials, reduction in need for immediate adult reassurance, and internalization of the work cycle that consists of selecting material, working, checking, and subsequently returning the material. Ability to finish initiated activities, sustain attention, and adapt to work structures varied among participants.

The individual differences are significant, given the qualitative nature of the study. Observed changes cannot be separated from individual characteristics of the participants, their prior experiences, and the manner in which they responded to the prepared environment. Furthermore, based on these four cases, it is not possible to determine to what extent the observed changes were linked to the interventions and to what extent they may have been related to natural development, kindergarten experiences, or other factors outside the research interventions.

Overall, the results suggest potential qualitative changes across several monitored areas—most notably in detail processing, drawing organization, model reproduction accuracy, independence, use of error control, and work organization. However, given the small sample size, exploratory nature of the study, and inability to control for other developmental and environmental influences, these findings primarily represent avenues for further investigation.

Discussion

Findings of this study suggest the observed changes cannot be interpreted in isolation from the broader

context of child development. Children's individual characteristics, prior experiences, family and educational environments, as well as individual biological and developmental predispositions, enter into learning and developmental processes. The need to reflect on educational paradigms is therefore also related to findings from neuroscience and cognitive science, which highlight the importance of individual differences in learning and development processes.

In addition, the findings point to the potential significance of educational environments that support autonomy, concentration, and active learning. The extent and nature of the observed changes varied among individual participants, and the initial performance level alone did not determine the pattern of subsequent changes. Given the small research sample, however, these observations cannot be interpreted as evidence of the effect of the Montessori environment. Rather, they may suggest that an educational environment respecting individual pace and providing opportunities for repetition, self-correction, and working at one's own pace can create conditions under which diverse individual developmental trajectories may manifest.

These findings can be contextualized with the review study by Long et al. (2022), which suggests Montessori schools in the United States educating children aged 3 to 6 years enroll a slightly higher proportion of children with learning disabilities than do traditional schools. Given that Montessori pedagogy respects individual learning paces and does not focus primarily on uniform performance standards, it can be assumed that such an environment may create conditions suitable for children with diverse developmental needs. In this context, Afshan et al. (2022) reported changes in cognition, independence, self-care, and communication in children with intellectual disabilities educated in a Montessori environment compared to children educated through traditional approaches.

Similar findings are presented by Dogru (2015), who found that 5- to 6-year-old children with ADHD demonstrated greater changes in attention following an intervention in a Montessori environment than did children educated under traditional conditions. Dogru connects this difference to the nature of the didactic materials, which engage movement, sensory perception, and hand–eye coordination, as well as to work organization allowing for longer uninterrupted work periods.

During the interventions, children had access to only one instance of each didactic material, reflecting the organization of a Montessori environment. Such an arrangement can support behavioral regulation, delay of gratification, and planning of subsequent activities (Tiryaki et al., 2021). During situations in which a material was not immediately available, children spontaneously organized alternative activities or later returned to the material. These situations can be viewed as context in which certain components of executive functions—particularly planning, inhibition, working memory, and cognitive flexibility—could be exercised (Kovalčíková et al., 2015). Given the study design, however, it cannot be determined to what extent these manifestations were directly related to the interventions.

The observed changes in selected areas can also be interpreted in connection with systematic work focused on details, categorization, and precise processing of stimuli during the interventions. In Controlled Drawing Observation, for example, more detailed drawings of a human figure and an animal appeared in the posttest for some participants, including more clearly rendered fingers, limbs, fur details, or limb terminations. Additional elements also appeared, such as a chimney on the house. For some participants, a more precise execution of specific instructions was observable—for example, in the request to draw a house with a pointed roof, placing a ball in the center of the sheet, or organizing individual parts of the drawing in designated areas of the workspace.

However, these changes cannot be directly attributed to the implemented interventions, as drawing and the aforementioned test tasks were not subject to specific practice. One can only consider repeated work with materials requiring perception, discrimination, and processing of details created a context in which these manifestations could emerge. Such an interpretation therefore remains hypothetical.

The nature of the language materials, which were based on perceptually salient and prototypical phenomena, may also have played an important role (Bloom, 2015; Vužňáková, 2018a, 2018b, 2020a). Language is therefore not understood in isolation in this research, but as part of broader cognitive processes related to attention, categorization, working memory, and organization of experience. Work with language material and speech stimulation served primarily as a means to create educational situations in which learning processes and selected developmental manifestations could be observed.

I assume some of the observed changes in the T–32 Drawing Copy Test may have been related also to the

manner of working with didactic materials, particularly through practical manipulation, selecting, matching, inserting, and rearranging individual elements. In the posttest drawings, a more accurate reproduction of certain more complex shapes appeared across multiple participants, particularly of the six-pointed star, the five-pointed star in a pentagon, the rhombus, the rhombus with a cross, or the pinwheel. Drawings in these cases appeared more detailed, precise, and systematically organized. Such changes may point to a shift in mode of visual processing of the model and its graphomotor reproduction; however, their origins cannot be unequivocally determined given the nature of the research.

Similar findings are reported by Bhatia et al. (2015), who found 5-year-old children in a Montessori group demonstrated greater accuracy and speed, and more consistent hand dominance, after eight months of intervention compared to children in a traditional group. Further research suggests hand motor activity can support thinking, problem-solving, and working memory, especially when concurrent with cognitive activity (Vallée-Tourangeau et al., 2015).

Observations indicated that changes concerned not only the products of children's activities but also the manner of work and behavioral manifestations during interventions. For several participants, the need to repeatedly seek verbal reassurance from an adult—such as asking whether they were performing the task correctly—gradually decreased. The children progressively learned to utilize error control mechanisms built into the materials. In some participants, this process manifested in the ability to independently check their own work upon task completion, identify an error, and subsequently correct it without direct adult intervention.

A concrete example was the gradual adoption of the work cycle: working with material → checking → returning the material to its initial state → placing the material back in its designated spot. One participant understood the principle of error control at an earlier stage of the interventions than did the others and was later able to apply it independently. Another participant, who initially required repeated adult reassurance, gradually began using the material's control mechanisms as tools for subsequent self-checking. These individual differences show adaptation to the principles of independent work did not proceed at the same pace for all children.

The observations can be cautiously interpreted in relation to the principles of Montessori pedagogy, in which error is part of the learning process and error control can gradually shift evaluation of performance from external adult control to the child's self-evaluation. In this sample, spontaneous manifestations of greater confidence in one's performance and less need for ongoing reassurance emerged. However, such manifestations cannot be considered universal outcome of intervention, as the extent and mode of expression varied among individual participants.

Despite observed changes, some children continued to experience difficulties processing longer and more complex instructions. This phenomenon appeared primarily in tasks requiring simultaneous processing of multiple criteria—such as a specified number of geometric figures combined with their size or spatial arrangement. For example, participants were able to independently draw the requested number of triangles, circles, or squares; however, in combined instructions such as "draw three triangles so that the middle one is the smallest" or "draw four circles so that two of them are the same size," errors occurred in counting or in simultaneous application of all requested characteristics. Similarly, difficulties with retaining and subsequently executing longer instructions persisted in some participants.

The findings are also important because the aforementioned abilities were not explicit targets of the implemented interventions. Persisting difficulties support a cautious interpretation of the results and do not allow for claims of general improvement in cognitive functioning. Rather, they highlight the uneven nature of the observed changes, by which certain manifestations altered as others remained relatively stable or manifested ambiguously. This finding corresponds to the individual nature of cognitive development and language acquisition. Vužňáková (2018a) emphasized that individual innate predispositions influence the pace of development and the functioning of the central nervous system and cognition.

Similar individual variability was observable in the adaptation to work organization. My observations suggest that even children previously educated predominantly in traditionally organized educational environments were able to gradually adapt to certain principles of Montessori pedagogy. For several participants, more independent utilization of their workspace, longer task persistence, independent work verification, and internalization of the work cycle gradually emerged. However, one participant continued to exhibit difficulties sustaining attention on a single activity and completing every initiated task even at the conclusion of the course of interventions. This case highlights that simple exposure to a new

educational environment may not lead to the same mode of adaptation in all children, underscoring need for an individualized approach in education.

The pace and extent of adaptation likely depend on multiple factors, including prior experiences, duration of exposure to the given environment, intensity of educational practice, and children's individual characteristics. Observed differences among participants support the need to interpret educational interventions not as a uniform factor acting equally on all children, but within the context of each child's individual development.

Limitations of the Study

Several limitations of this research must be noted. A primary limitation is the temporal duration of the study and limited number of intervention sessions, which did not provide sufficient scope to evaluate the long-term trajectory of monitored manifestations. The sample selection was opportunistic, consisting of only four children from a single kindergarten classroom. Consequently, the sample was not representative of the broader population of preschool-aged children, and findings obtained cannot be generalized statistically or conceptually.

Another limitation stems from the fact that observation, test administration, and intervention implementation were conducted by a single researcher acting simultaneously as observer, assessor, and intervention facilitator. The multiple roles may have influenced the observation process and data interpretation, representing a potential source of interpretive bias. To mitigate this, I strove for maximum transparency and systematicity during analysis, primarily by triangulating multiple data sources—direct observations, video recordings, individual testing results, products of child activity, and available behavioral evaluations from parents and teachers.

I acknowledge the observed changes may have been partially influenced by children's natural maturation, their experiences in kindergarten, the family environment, or other factors outside the implemented interventions. Because the study was designed as an exploratory qualitative investigation using a multiple-case study approach, its objective was neither to isolate the effect of a single variable nor to demonstrate a causal relationship between the interventions and observed changes.

Therefore, I do not generalize the results to the wider population; rather, I view them as highlighting certain individual tendencies and potential connections between characteristics of the educational environment, learning processes, and selected manifestations of cognitive, perceptuomotor, and behavioral development in preschool age. Specific instances—such as more precise adherence to the instruction to draw a house with a pointed roof, better placement of the ball in the center of the sheet, more detailed depictions of the figure and animal, or more accurate reproduction of certain complex shapes—represent individual examples of observed changes that must be interpreted within the context of the overall case analysis. Similarly, the reduced need for ongoing adult reassurance, gradual adoption of error control, and more autonomous organization of the work cycle represent observed behavioral manifestations rather than evidence of a universal effect of the Montessori intervention.

Despite the limitations, the findings underscore the need for further investigation into the relationship between the nature of the educational environment and children's learning and developmental processes. Future research could track these phenomena across larger and more diverse samples, over longer time frames, and utilizing research designs that better distinguish natural developmental progression from intervention-related changes. Additionally, there is a clear need to more thoroughly examine the mechanisms through which specific features of an educational environment may relate to learning, autonomy, concentration, and other developmental manifestations in children. Further exploration of these phenomena is well justified, particularly in the context of ongoing educational reforms and growing insights into learning processes.

The results of this study point to specific individual changes and tendencies that can serve as foundational for future research into conditions supporting learning and development in preschool-aged children.

Conclusion

This study examined potential connections between an educational environment based on the principles of Montessori pedagogy and selected manifestations of cognitive, perceptuomotor, and behavioral development in preschool-aged children. Particular attention was devoted to task comprehension and execution, work organization, attention, independence, self-monitoring of performance, error handling, detail processing, and visuomotor reproduction.

Throughout the monitored period, individual changes in task execution modes and work organization were observed across activities of all four participants.

In some cases, greater independence, reduced reliance on immediate adult reassurance, gradual utilization of error control mechanisms, and more systematic work organization emerged. In testing situations, multiple participants demonstrated qualitative changes regarding detail processing, spatial drawing organization, and accuracy of reproducing specific models. However, these changes were not uniform across all monitored domains or in all children.

I consider it particularly significant that observed changes manifested even in areas that were not direct instructional targets of the interventions. Intervention activities focused primarily on selected language and communication phenomena, and the materials utilized simultaneously created conditions for manipulation, categorization, independent self-checking, task repetition, and personal work organization. The results thus support the study's baseline premise that language, cognitive, perceptuomotor, and behavioral processes cannot be fully separated within natural learning processes.

Findings demonstrated individual variability in the course and extent of observed changes. Certain difficulties—particularly in processing longer and more complex instructions or applying multiple conditions simultaneously within a single task—persisted post-intervention. This suggests individual developmental domains may not shift at identical rates and that a child's response to an educational environment may be linked to their unique characteristics and prior experiences.

Consequently, I do not interpret the results as evidence of a causal effect of Montessori interventions or as proof of general effectiveness of Montessori pedagogy. Observed changes may have been related not only to the nature of the implemented interventions, but also to children's natural maturation, prior experiences, school and family environments, repeated exposure to assessment contexts, and other factors that could not be controlled within this research design.

Interpretation must also take into account the study's limitations. The investigation was conducted on a small, nonrepresentative sample of four children, the duration of interventions was limited, and the researcher concurrently served as observer, assessment administrator, and intervention facilitator. Furthermore, given their integration into a broader research project, the intervention content targeted only select language-communication phenomena. For these reasons, I do not generalize the results to a broader population, but understand them as individual observations and indications of certain tendencies that require further verification.

Despite its limitations, the study highlights the importance of investigating educational conditions that allow children to autonomously organize their activity, work at their own pace, repeat tasks, utilize performance self-checking, and actively participate in the learning process. The findings simultaneously support the need to comprehensively examine educational environments, accounting for the interrelationships among language, cognition, motor skills, and behavior.

Future research should track these phenomena across larger and more diverse child samples, over extended time frames, and through a combination of qualitative and quantitative methods capable of more precisely distinguishing individual developmental changes from shifts related to the nature of the educational environment. Such investigation remains highly relevant within the context of contemporary educational reform and expanding insights into children's learning processes.

The overall contribution of this study thus lies not in confirming the efficacy of a single educational method, but in identifying specific manifestations of learning and development that altered within the observed educational environment, representing a well-justified focus for future research.

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