Colloquium

L'effetto Proust: olfatto, memoria e narrativizzazione dell'esperienza

A cura di
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Sensory Education: Learning through the Sense of Smell

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ABSTRACT: The sense of smell, often underestimated, is a powerful tool in education and instruction thanks to its direct connection with perceptual systems, sensory memory and emotions through the limbic system. The integration of olfactory stimuli in learning environments sometimes precedes and sometimes supports and enhances linguistic and cognitive functions, as well as the understanding of experiential processes, ideas that find broad scientific consensus around the framework of neurovariability. Recent research indicates that sensory functions are closely related to developmental processes. Sensory processes support perceptual experiences, memory and, consequently, complex cognitive and learning processes throughout all stages of life, however, the degree of neural plasticity appears to be higher in the early stages of development than in adulthood. Through the paradigms of neuroeducation and multi-sensory learning theory, some possible avenues for study and research are highlighted on the relationship between teaching-learning and olfactory perception and on the applications of sensory teaching in educational and school contexts.

KEYWORDS: brain-inspired learning; multi-sensory learning; neuroeducation; neurovariability; olfactory experiences; sensory education.

1. Introduction

1.1. *Multi-sensory learning theory perspective*

The suggestion is that multi-sensory experiences, visual, auditory, tactile, olfactory, promote learning; does identifying the brain regions involved in cognitive processes genuinely enhance our understanding, or does such information simply add superficial appeal? The debate is not new.

The multi-sensory theory, which emphasizes the integration of multiple sensory modalities, has been fundamental to understanding human perception and information processing. By engaging several senses simultaneously – visual, auditory, tactile, and other perceptual channels – learning and memory can be notably improved[1]. The theory has been

[1] Ahmad Naufal, Amalia Suzianti, «Design Thinking Approach for Product Innovation Design of Educational Toys», in *Proceedings of the 5th International Conference on*

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incorporated into various disciplines [2] influencing cognitive science, affective and social neuroscience, cultural heritage conservation, but also product design, where multi-sensory engagement became central to enhancing user experience. This long-standing intellectual development underscores the theory's cross-disciplinary relevance [3].

The concept of a multi-sensory approach, while not novel, has gained substantial traction in recent years. By harmoniously integrating various sensory channels, children's engagement in the learning process is amplified. This heightened involvement stems from the activation of multiple senses, which collectively craft a more immersive educational experience. The multi-sensory method can also spur creativity, prompting children to adopt innovative thought processes and explore beyond conventional boundaries [4].

Another theoretical approach supporting sensory education, whose foundations can be traced to recent neuroscientific discoveries regarding learning processes, is Universal Design for Learning (UDL [5]). The model rests is based on the idea that educational experiences should engage multiple cognitive modalities, the different means of representation, expression, and engagement become possible by drawing on the individual's sensory abilities, depending on cir- cumstances and on the stimulation of individual sensory abilities.

Sensory education, for example, has its roots in the different systems of perception, visual, auditory, and somatosensory.

Human cognition inherently operates on a multi-sensory level, where the brain actively seeks to combine information from various sensory channels to form a cohesive understanding of the world around us. This integration of sensory inputs is not just a passive amalgamation; it's

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E-Business and Mobile Commerce (ICEMC 2019), New York, Association for Computing Machinery (ACM), 2019, pp. 69-74.

[2] Jan D'hooge, Andreas Heimdal, Farida Jamal, Tomasz Kukulski, Bart Bijnens, Frank Rademakers, Liv Hatle, Paul Suetens, George R. Sutherland, «Regional Strain and Strain Rate Measurements by Cardiac Ultrasound: Principles, Implementation and Limitations», *European Journal of Echocardiography* 1, 3 (2000), pp. 154-170.

[3] Judith Holler, Stephen C. Levinson, «Multimodal Language Processing in Human Communication», *Trends in Cognitive Sciences* 23, 8 (2019), pp. 639-652; Fan Yijun, Chong Daphne Khee, Li Yuanzhe, «*Beyond Play*: A Comparative Study of Multi-Sensory and Traditional Toys in Child Education», *Frontiers in Education* 9 (2024), 1182660.

[4] Fan, Chong, Li, «*Beyond Play*: A Comparative Study of Multi-Sensory and Traditional Toys in Child Education».

[5] Center for Applied Special Technology (CAST), *UDL and the Learning Brain*, Wakefield (MA), CAST, 2018.

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a dynamic process that plays a pivotal role in shaping our perceptions, memories, and learning experiences[6]. External stimuli, whether visual cues from a book, auditory signals from a lecture, or tactile feedback from a hands-on activity, are processed and assimilated through various senses. multi-sensory approach to processing not only enriches our comprehension of the received information but also ensures that learning is more robust and durable[7].

1.2. *Neuroeducation perspective*

Educational neuroscience research has traditionally focused on individual learning, examining the neural and behavioral changes that occur during learning. A recent line of research investigates the neural activity of both learners and teachers. This research explores the neural correlates of information transfer, communication, and social interaction in the learning environment.

According to the 4E Cognition Framework[8] – *Embodied*, *Enactive*, *Embedded*, and *Extended Cognition*[9] – our understanding of the world would be shaped by more than just our brains; our cognition is fundamentally linked to our physical bodies and sensory experiences. The way we perceive the world is influenced by our senses (sight, touch, taste, smell, and hearing) and how we interact with our surroundings.

For educational neuroscience, the concepts of embodied cognition and embodied learning emerging from the 4E model hold significant promise. These concepts provide a potential epistemological foundation for the field. Specifically, there's value in revisiting ideas related to sensory teaching that emphasizes how learning can be enhanced by engaging the senses[10].

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[6] Chen Chen, Nurullizam Jamiat, «A Quantitative Study on the Effects of an Interactive Multimodal Application to Promote Students' Learning Motivation and Comprehension in Studying Tang Poetry», *Frontiers in Psychology* 14 (2023), 1189864.

[7] Gunther Kress, Carey Jewitt, Jon Ogborn, Charalampsos Tsatsarelis, *Multimodal Teaching and Learning: The Rhetorics of the Science Classroom*, London, Continuum, 2001.

[8] Olivier Houdé, *3-System Theory of the Cognitive Brain: A PostPiagetian Approach to Cognitive Development*, London - New York, Routledge, 2019.

[9] Lawrence Shapiro, *Embodied Cognition*, London - New York, Routledge, 2019.

[10] Giancarlo Gola, *Educational Neuroscience in the Classroom*, Newcastle upon Tyne (UK), Cambridge Scholars Publishing, 2024.

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The principles deduced from neuroeducation studies frequently have a general validity, that is, they can be applied, perhaps better translated, in different and multiple contexts, to all students, even those who show special cognitive needs. In fact, to maximize learning, one should use as many neuroeducational strategies as possible. The human brain has the natural capacity to learn, and the process continues beyond classroom learning.

Neuroeducation approach, which builds on the assumptions and elements of *Mind Brain Education* and *Bioeducational Sciences* within education, proves to be crucial to fully understand learners' cognitive mechanisms and to make the teaching and learning process more effective. There are numerous models and interventions that fall under the perspectives associated with neuroeducation. It is possible to promote an optimal learning cycle that goes hand in hand with optimal brain functioning, in which appropriate learning opportunities have an extraordinary impact on development or the cognitive abilities that are supported. These skills, in turn, are essential for coping with challenges in school, extracurricular and social contexts. Adaptability to changes in the nervous system promotes the strengthening or weakening of existing neural connections. The brain continually shapes and adapts with experiences. The concept of genetic determinism can therefore be contrasted with the idea of enhancing synaptic efficiency through new synaptic connections, changes, and reinforcements, which can also occur through the senses, such as smell.

Neuroscience offers valuable insights that can influence education in numerous ways, these include also the sensory function in facilitating adaptation and learning[11]. Neuro-teaching, particularly, which applies brain research to education, goes beyond studying the brain itself. It also considers factors like motor skills, perception, and sensory functions. This broader approach provides valuable tools for understanding and improving teaching and learning, paving the way for innovative educational practices.

2. The sensory processes

Common sensory principles extend to neural systems. Although humans rely less on their olfactory sensory system than other animal species, the ability to perceive odors is still innate. It does not depend directly on behavior, even though it can be developed through exercise, but rather

[11] *Ibidem*.

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on a multiplicity of receptors in the nasal cavities, specific regions of the cerebellum and interconnecting nerve pathways, which respond to the encoding of many different odor stimuli through a complex system of transduction via receptor cells, support cells and basal cells. The molecular mechanisms of transduction are very similar to the signal generation system that every cell in the body uses for very different functions. There are molecular similarities, for example, between the sensory cells of sight and smell, and common sensory principles also extend to the neural system level to respond to detailed perceptions. For those who study the interconnection between sensory systems and learning processes, the concept of a sensory map is useful, an orderly distribution of neurons that represents certain characteristics of the sensory world, including spatial olfactory maps[12]. These are believed to distinguish the different chemicals contained in different odors. Unlike other stimuli, such as sound and sight, odor stimuli appear to be processed more slowly, suggesting that the temporal neural coding of odors is a qualitative identification. Research has not yet fully demonstrated that the brain is able to use the information from neural maps in response to stimuli, only to a limited extent.

Little is still known about the spatial organization process of olfactory discrimination. Current research indicates that olfactory signals assume an almost topographical organization within the bulb, similar to what happens with other sensory modalities. This arrangement forms the basis through which neurons in the prefrontal cortex can receive and transform signals into the perception of a specific odor. From a functional point of view, the affective and emotional aspects of olfactory sensation are mediated by olfactory projections to the limbic system (entorhinal cortex, hippocampal formation, medial septal nuclei, amygdala). In this sense, responses to olfactory stimuli can have interesting implications for learning.

3. Learning through the sense of smell

Empirical research confirms the efficacy of olfactory cues in improving memory recall. Olfactory experiences are inherently contextual and culturally influenced, which can be leveraged in educational settings to enhance cultural awareness and inclusivity. Smell-based activities, such as using traditional aromas from various regions, can promote intercul-

[12] Venkatesh N. Murthy, «Olfactory Maps in the Brain», *Annual Review of Neuroscience* 34, 1 (2011), pp. 233-258.

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tural understanding while stimulating sensory engagement. Research in olfactory heritage emphasizes aspects of smells that are related to cultural practices and spaces with unique and integral values for identity and place-making for communities [13]. For example, studies using scents have demonstrated improved focus and retention among learners exposed to these odors during study sessions [14]. These findings align with the broader understanding of sensory encoding in memory consolidation. Research in Norwegian kindergartens highlight the potential of olfactory experiences to enrich multi-sensory learning. Activities like «smell walks» and the use of «smell maps» have been employed to help children explore their environments and develop sensory literacy [15]. These practices not only engage children cognitively but also deepen their emotional connection to the learning material [16]. Olfactory stimuli can significantly influence the emotional tone of a learning environment. Calming scents, such as lavender or chamomile, have been shown to reduce stress and anxiety among learners, particularly in special education contexts. Conversely, energizing scents, such as citrus, can enhance alertness and engagement during challenging tasks. Olfactory perception characterized by its intensity, speed of perception, and the breadth of stimuli, plays a pivotal role in cognitive efficiency [17].

3.1. *Education and olfactory experiences*

The synergy between senses is especially crucial in early childhood development, where sensory experiences lay the foundation for complex cognitive functions in later life [18].

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[13] Cecilia Bembibre, Matija Strlič, «Smell of Heritage: A Framework for the Identification, Analysis and Archival of Historic Odours», *Heritage Science* 5 (2017), 2.

[14] Naufal, Suzianti, «Design Thinking Approach for Product Innovation Design of Educational Toys».

[15] Natalia Kucirkova, Ida Bruheim Jensen, «Children's Early Reading through the Sense of Smell: A Typology of Olfactory Engagement», *Early Child Development and Care* 193, 15-16 (2023), pp. 1589-1606.

[16] Natalia Kucirkova, Monika Kamola, «The Significance of Children's Olfactory Experiences in a Norwegian Kindergarten: An Olfactory Researcher-Practitioner Collaboration», *Educational Action Research* 32, 4 (2024), pp. 586-605.

[17] Cai Hao, Xiao Hanlin, Tong Chengxin, Dong Xian, Chen Shilong, Xu Feng, «Influence of Odor Environments on Cognitive Efficiency: A Comprehensive Review», *Science of the Total Environment* 949 (2024), 174642.

[18] Anthony D. Pellegrini, «Rough-and-Tumble Play from Childhood through Adolescence: Differing Perspectives», in *Play from Birth to Twelve and Beyond: Contexts,*

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The concept of a multi-sensory approach, while not novel, has gained substantial traction in recent years. By harmoniously integrating various sensory channels, children's engagement in the learning process is amplified. This heightened involvement stems from the activation of multiple senses, which collectively craft a more immersive educational experience. The multi-sensory method can also spur creativity, prompting children to adopt innovative thought processes and explore beyond conventional boundaries[19]. Innovations in children's literature, such as olfactory picture books, integrate smell to create immersive reading experiences. These books utilize scent as a narrative device to deepen comprehension and make abstract concepts tangible, fostering engagement and enhancing the reading experience for young learners. Beyond olfactory-specific learning, exposure to odors has been shown to influence other sensory modalities. For instance, olfactory stimuli have been linked to improved spatial navigation and visuospatial memory, suggesting broader cognitive benefits. Incorporating olfactory elements in classroom settings, such as aroma-infused materials or activities centered on smell exploration, can create a stimulating environment that enhances sensory and cognitive development. Although the sensory, affective and aesthetic practices are more prominent in early childhood settings that follow the Montessori and Steiner tradition, typical Western early childhood classrooms do not foreground sensory learning.

Learners exhibit diverse sensory preferences and sensitivities. While some may find certain scents stimulating, others might react adversely. Tailoring olfactory inputs to individual needs is crucial for maximizing their educational benefits.

The sense of smell also interacts with other sensory modalities and is involved in representational processes for information acquisition and processing[20]. The synergy between senses is especially crucial in early childhood development, where sensory experiences lay the foundation for complex cognitive functions in later life[21].

For students with special educational needs (SEN), for example, olfactory-based learning offers unique advantages. Sensory learning rooms incorporating olfactory inputs have increased engagement and

Perspectives, and Meanings, edited by Doris Pronin Fromberg and Doris Bergen, London - New York, Routledge, 3rd ed. 2015, pp. 401-408.

[19] Fan, Chong, Li, «*Beyond Play*: A Comparative Study of Multi-Sensory and Traditional Toys in Child Education».

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reduced anxiety among autistic learners, highlighting the therapeutic and educational potential of smell-based interventions. Associating scents with specific tasks also aids students with ADHD or dyslexia in focusing and retaining information. The concept of neurovariability is important for educators, it reminds us that learners do not have an isolated learning style, but instead rely on many parts of the brain working together to function within a given context. Learners exhibit diverse sensory preferences and sensitivities.

Although evidence-based education research still reports mixed findings regarding the relationship between learning environments and learning outcomes, the charateristic of the environment in which the learner develops are fundamental. Much attention is paid to the enriched environment, also with reference to pre-school and school environments. An enriched environment is a combination of complex inanimate and social stimuli [22] that offers the opportunity for multiple visual, olfactory, somatosensory, motor, cognitive and social stimuli of varying complexity, capable of promoting greater neural plasticity, synaptic connections and neurogenesis phenomena, which support learning abilities and outcomes.

From a neuroeducation perspective, culturally rich and linguistically demanding environments function as biologically inspired learning systems that align with the brain's intrinsic organizational principles [23]. More generally, making inferences from sensory data in an enriched environment requires the ability to represent the world in one's brain, make decisions and assumptions, and act on them.

3.2. *Discussion*

Education and olfactory experiences intersect in a manner that reveals the profound depth of human learning, illuminating how cognition is not merely a disembodied intellectual exercise, but a process intrinsically tied to the sensory fabric of everyday life. Although the olfactory sense has historically been regarded as peripheral within educational discourse,

[22] Bruno Will, Rodrigue Galani, Christian Kelche, Mark R. Rosenzweig, «Recovery from Brain Injury in Animals: Relative Efficacy of Environmental Enrichment, Physical Exercise of Formal Training», *Progress in Neurobiology* 72, 3 (2004), pp. 167-182.

[23] Evgenia Gkintoni, Stephanos P. Vassilopoulos, Georgios Nikolaou, «Brain-Inspired Multisensory Learning: A Systematic Review of Neuroplasticity and Cognitive Outcomes in Adult Multicultural and Second Language Acquisition», *Biomimetics* 10, 6 (2025), 397.

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recent interdisciplinary research demonstrates that smell exerts a subtle yet powerful influence on attention, emotion, memory, and conceptual understanding, suggesting that its marginalization in mainstream pedagogy reflects cultural habit rather than scientific necessity. Integrating olfactory stimuli into educational environments invites a reconceptualization of learning as an embodied practice, wherein both the acquisition and organization of knowledge depend not solely on linguistic or visual mediation but on the dynamic interplay of sensory inputs that together shape the learner's perceptual field. This shift in perspective aligns with contemporary cognitive science, which views perception as an active process of meaning-making; odors are not merely detected but interpreted, positioned within autobiographical memory and contextualized through social experience. When incorporated thoughtfully into educational settings, olfactory cues can therefore support learners in forming richer mental representations, guiding the processes of inference, anticipation, and abstraction that underpin more complex reasoning. An educational environment that recognizes the pedagogical relevance of smell does more than add an additional sensory layer; it challenges the implicit hierarchy of the senses that has long structured Western schooling, where vision and audition typically dominate while other sensory channels are relegated to the periphery. In doing so, it opens space for considering how different modalities contribute distinctively to cognitive development and how their convergence fosters more adaptive forms of learning. The olfactory sense, with its direct neural pathways to limbic structures associated with emotion and memory, occupies a particularly intriguing position: unlike visual or auditory information, which is subject to several stages of cortical processing, olfactory information can trigger immediate affective responses that shape motivation and readiness to learn, thereby creating favorable or unfavorable conditions for intellectual engagement.

Neuroevolutionary integration of learning occurs through shared plasticity mechanisms, with exposure to culturally relevant stimuli producing neural efficiencies in the same executive and memory systems that support language acquisition. This convergence suggests that sensory learning also shares neuroevolutionary pathways, reducing cognitive load and improving semantic integration by supporting natural language acquisition processes[24].

[24] Nabil Bouizegarene, Maxwell J.D. Ramstead, Axel Constant, Karl J. Friston, Laurence J. Kirmayer, «Narrative as Active Inference: An Integrative Account of Cognitive and Social Functions in Adaptation», *Frontiers in Psychology* 15 (2024), 1345480.

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This mechanism suggests that olfactory cues can function as subtle regulators of the learning climate, influencing students' sense of belonging, emotional stability, and willingness to participate. In higher education contexts, where abstract thinking and advanced conceptual integration are central, olfactory stimuli may appear irrelevant; however, even in these settings, the strategic use of scent can support reflective thinking, help manage cognitive load, and stimulate associative connections that generate novel insights. For example, certain olfactory environments can encourage sustained concentration during complex problem-solving tasks or prompt learners to revisit familiar concepts with renewed attentiveness, thereby enhancing metacognitive awareness. In addition, olfactory cues can assist learners in constructing disciplinary identities, particularly in fields where smell constitutes a legitimate mode of professional perception, such as chemistry, gastronomy, environmental science, or clinical practice. Here, the olfactory sense becomes a means of acquiring tacit knowledge, enabling learners to grasp nuances that cannot be fully captured by theoretical description alone. This form of experiential learning challenges the assumption that expertise is solely cognitive; instead, it foregrounds the embodied dimensions of professional judgement and highlights the interdependence between sensory refinement and intellectual mastery. Moreover, olfactory experiences can foster intercultural sensitivity by introducing learners to scent-based practices, rituals, and materials from different cultural traditions, thereby expanding their awareness of how societies construct meaning through sensory experience. Odors carry cultural inscriptions, and their interpretation varies across contexts; what is perceived as comforting or familiar in one community may be regarded as intrusive or unpleasant in another. Recognizing these differences encourages educators to situate olfactory learning within an ethical framework that respects individual and cultural variability, foregrounding sensitivity rather than uniformity. Such an approach demands a nuanced calibration of sensory environments, where the aim is neither to overwhelm learners with intrusive stimuli nor to impose standardized sensory norms, but to cultivate atmospheres that are adaptable, inclusive, and supportive of diverse perceptual profiles. This is particularly relevant when considering learners with sensory processing differences, who may experience olfactory stimuli more intensely than their peers and for whom exposure to certain scents may trigger discomfort or anxiety. Designing educational environments that incorporate smell in a flexible, learner-centered manner thus requires ongoing assessment, iterative refinement, and open communication, ensuring that olfactory interventions do not inadvertently hinder but instead enhance the learning process. The move

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towards recognizing olfactory experience as educationally significant also intersects with wider philosophical discussions about the nature of knowledge and the role of the body in cognition. Approaches such as embodied cognition and enactivism argue that learning emerges from an interaction between the organism and its environment, suggesting that sensory engagement is not supplementary but foundational to thought. Within this view, olfactory learning becomes a means of cultivating epistemic agency, as learners develop an awareness of how their sensory encounters shape their understanding of the world. This perspective offers a powerful corrective to overly abstract conceptualizations of learning, emphasizing that intellectual growth is anchored in lived experience and that sensory modalities – including smell – provide essential scaffolding for the development of critical, imaginative, and reflective capacities. Furthermore, considering education through an olfactory lens encourages a broader re-evaluation of educational design, including architecture, materials, and spatial organization. Classrooms, laboratories, libraries, outdoor spaces, and virtual environments all possess distinct olfactory qualities that can influence learners' perceptions of safety, curiosity, and cognitive openness. Attending to these characteristics enables educators and designers to construct environments that support both wellbeing and intellectual engagement, aligning aesthetic considerations with pedagogical aims. Ultimately, the integration of olfactory experiences into education represents more than a methodological innovation; it signals a fundamental reorientation towards an understanding of learning as multisensory, relational, and deeply human. By acknowledging the pedagogical potential of smell, education becomes attuned to the subtle textures of experience that shape how individuals perceive, interpret, and participate in the world. Learning can therefore unfold not only through what is seen and heard but also through the evocative, memory-laden, and affectively rich domain of the olfactory.

Schools need to recover forms of teaching that activate all the senses and pay attention, for the purpose of learning, to the many possibilities for the development of cognition, including through the sensorial dimension, challenging the notion that knowledge can be acquired through a single pathway or primary mode[25]. Considering the body as a whole, sensory, motor, linguistic and cognitive functions, in education allows educators and teachers to develop more effective and targeted learning approaches. By incorporating practical experiences, physical movement

[25] Gola, *Educational Neuroscience in the Classroom*.

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and multi-sensory activities, teachers can facilitate deeper memorization and understanding by students.

Although promising, the field of empirical research on olfactory learning remains limited in comparison to other studies on sensory modalities, particularly in the pre-school and school environment. While the benefits are clear, practical challenges such as creating olfactory materials, tools and addressing individual differences in smell perception remain. Future studies could focus on the impacts and applications of olfactory-based educational strategies in response to the idea of variability of learning.

The emphasis on sensory integration underscores the need for an educational approach, where learners are encouraged to engage with content using all their senses, leading to deeper understanding and long-term retention[26]. Sensory education, particularly through the sense of smell, represents a transformative approach to learning. By tapping into the emotional and memory-evoking power of scents, educators can create engaging and effective teaching strategies. Integrating olfactory learning into education holds transformative potential, offering unique ways to engage learners and enhance cognitive and non-cognitive outcomes. By embracing this sensory dimension, educators can foster a richer, inclusive learning environment. Expanding research on multi-sensory learning and the learning through the sense of smell, coupled with practical innovations, will pave the way for a more inclusive educational paradigm.

The design of multi-sensory educational experiences is an important area of research that has the potential to improve learning, particularly during stages of neurocognitive development. The focus on keeping pupils engaged through a multi-sensory teaching approach is in line with the latest scientific principles of neuroeducation and neurocognition. By incorporating these principles, neuroteaching can offer a more engaging and immersive learning experience.

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