

BIENESTAR PSICOLÓGICO Y DIGITALIZACIÓN: EL GRAN RETO DE LA PSICOLOGÍA HOY

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Celestino Rodríguez
(eds.)



Editorial ASUNIVEP

The creative brain in education: Integrating neuroscience, movement, and contemplative practices for holistic development

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Abstract

A holistic, integrated educational model that equally values physical movement, emotional intelligence, and cognitive development is essential for student well-being. In this context, creativity is increasingly recognized as a critical capacity for navigating 21st-century challenges yet remains underdeveloped in educational systems that prioritize standardization over holistic child development. This paper introduces a neuroscience-based framework for integrating embodied and contemplative practices—such as Yoga and Quadrato Motor Training (QMT)—into school curricula. Grounded in the Sphere Model of Consciousness (SMC), this framework connects cognitive flexibility, emotional regulation, and self-awareness to academic and social-emotional learning outcomes. By examining existing literature and presenting new data from school-based implementations, we demonstrate how integrating movement, meditation, and neurofeedback can enhance creativity, attention, and well-being. We offer policy and research recommendations to position creativity as a core educational competency, supported by scalable, cost-effective, and evidence-informed practices.

Keywords: creativity, meditation, embodiment, education, neuroscience

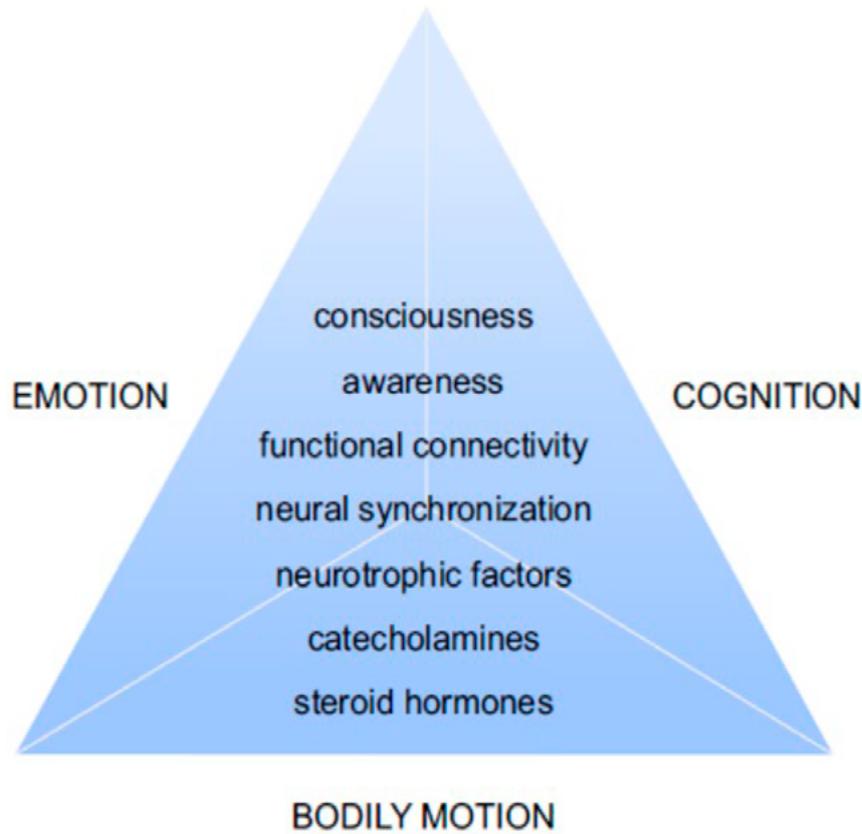
Introduction

Reframing creativity in education

In a world shaped by rapid technological transformation, environmental crises, and global interconnectedness, the ability to think creatively and flexibly is not a luxury but a necessity. While decades of research have consistently shown that well-designed and implemented classroom-based prevention programs can reduce conduct problems while building skills for mental health and academic achievement (Broderick & Metz, 2016) the rise in emotional distress in younger populations in recent years appears (Meade, 2021) to be heighten the need to intervene regardless of pre-existing vulnerabilities, and prioritize the teaching of effective emotion regulation skills and enhance executive functions (EFs, namely cognitive processes such as working memory, cognitive flexibility, and inhibitory control, all essential for adaptive learning and problem-solving), not just to those at increased risk of problems, as part of comprehensive Social Emotional Learning (SEL) programming (Lawlor, 2016). For example, children and adolescents are experiencing significant anxiety and depression during and following the COVID-19 pandemic, emphasizing the need to access to solutions and coping tools (Paoletti *et al.*, 2022). Yet many educational institutions remain structured around outdated paradigms that prioritize rote memorization, standardization, and passive knowledge acquisition. Based on state-of-the-art neuroscientific knowledge from our lab and from the growing literature in the field, we argue that creativity, far from being a secondary skill, is central to human flourishing and should be systematically cultivated in schools.

Figure 1

The interconnectedness between motion, emotion and cognition and the possible dimensions that need to be examined to achieve a comprehensive overview of the effects of training for healthy development



Note. Adapted from Paoletti (2008) and Pesce & Ben-Soussan (2016)

As the overall increasing percentage of children, adolescents, and adults who suffer from mental health disorders, a holistic and inclusive approach to child and adolescent development is needed, to promote long-term health and well-being, acknowledging that harmonic development includes the integration of physical, cognitive, psychological, social, and emotional domains (Stodden *et al.*, 2023). In this context, it's important to note that while aerobic exercise and resistance training are frequently recommended for enhancing brain health, such interventions have produced the weakest and most inconsistent benefits for EFs compared to other methods, such as cognitively engaging physical activities like martial arts or mindfulness-based practices (Diamond & Ling, 2019). Although some studies show modest benefits, the majority fail to demonstrate significant improvements in EFs, especially when interventions lack cognitive or emotional engagement. In fact, the most effective way to enhance academic and cognitive outcomes is by addressing all aspects of the child—cognitive, emotional, social, and physical needs—rather than narrowly focusing on academic content alone (Diamond, 2010). Emotional well-being, social belonging, physical activity, stress reduction, and meaningful engagement are all critical for optimizing EFs and learning. Relying on isolated, decontextualized tasks or high-stakes testing fails to develop essential skills like problem-solving, reasoning, and self-regulation. Therefore, interventions and educational practices that integrate cognitive challenges with emotional support, social connection, and physical engagement are likely to be the most successful in improving children's cognitive and academic outcomes.

In fact, as we shall see below, cognitive neuroscience and contemporary research highlights the role of embodied cognition, contemplative practices, and affective self-regulation in supporting well-being and creativity. However, few educational policies incorporate these insights into daily teaching. The

underuse of movement and mindfulness-based practices is particularly notable, with physical activity often limited to a single hour per week and silence framed as a disciplinary measure rather than a developmental resource. We propose that integrating embodied practices into classrooms (Lawlor, 2016), not just meditation and mindful movement, can foster not only cognitive flexibility but also empathy, reduced bullying, as well as enhanced focus and emotional resilience. Consequently, they may also lead to a greater sense of belonging and cooperation, while academically, it supported increased engagement, reduced absenteeism, and improved grades. In doing so, this paper builds upon existing school-based interventions—such as yoga—while introducing structured, neuroscience-informed practices that explicitly target creativity and EFs. Rather than positioning one practice above another, we advocate for a complementary model in which multiple embodied techniques can support, in different complementary ways students' cognitive, emotional, and social development.

Furthermore, we situate this work within the broader shift in educational psychology toward holistic child development, aligning with frameworks such as SEL emphasizing the importance of aiding students effectively apply not only knowledge, but also attitudes and skills necessary to identify and manage their emotions; understand another's perspective and show empathy; set and achieve positive goals; develop and sustain positive relationships; and make responsible decisions, which in turn require self-awareness, self-management, social awareness, relationship skills, and responsible decision-making, all closely related to cognitive flexibility (Eurich, 2018). This approach advances both theory and practice by exploring how structured body–mind training—embedded in a neurocognitive framework—can foster adaptive, self-aware learners prepared to thrive in uncertain times.

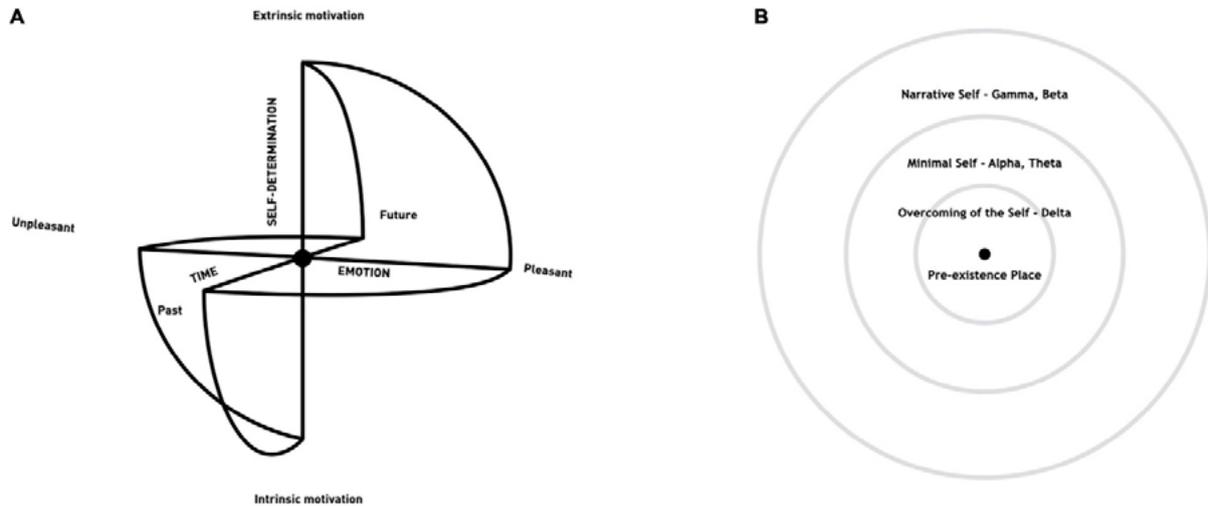
To further support our claim, we present key findings on the relationship between neural oscillations and self-awareness, derived from studies on Yoga and Quadrato Motor Training (QMT)—the latter being an innovative practice developed within the Sphere Model of Consciousness (SMC, Paoletti 2002) framework. Before doing so, let's detail on the SMC which has been defined as one of the most advanced models of consciousness and development today and its contribution.

Theoretical Framework: Embodiment and the Sphere Model of Consciousness (SMC)

The SMC, a neurophenomenological model of consciousness developed by Patrizio Paoletti, is a multidimensional framework to map human function across time, emotion, and self-determination (Paoletti & Ben-Soussan, 2019).. The model highlights how experiences of stress, emotional reactivity, and habitual behaviors (such as those seen in at-risk students) can be understood as dynamics occurring on the sphere's surface (Paoletti & Ben-Soussan, 2020), while practices like meditation or mindful movement—similar to yoga—help individuals reconnect with the equidistant, non-reactive center. Neurophysiological findings, particularly in meditative states, suggest that accessing this «center» fosters emotional regulation, cognitive flexibility, and reduced reactivity—benefits echoed in cognitive and contemplative research. Educationally, the SMC offers a compelling logic for integrating practices that cultivate awareness, such as yoga or mindfulness, into schools, supporting students in moving beyond surface-level stressors and fostering deeper self-regulation, learning readiness, and well-being. Electrophysiologically, this embodied state, which we can relate to the Minimal Self, experienced as the embodied self in the here-and-now, represents immediate, non-conceptual, pre-reflective self-awareness grounded in sensorimotor experience, is linked to increased alpha and theta activity (for a review see Paoletti *et al.*, 2022b), frequencies associated with bodily awareness, attention regulation, inhibition of distractions, and internal focus. Importantly, alpha, in particular, plays a key role in promoting cognitive flexibility and creative problem-solving by supporting internally-directed attention and suppressing irrelevant sensory input. These properties make alpha activity crucial not only for enhancing attentional control but also for supporting creative cognition and insight generation.

Figure 2

SMC and the mechanisms involved. The Narrative Self is considered as a self-image built through autobiographical memories and projections into the future; it involves awareness of personal identity and its continuity through time, as well as conceptual contents, while the Minimal Self emerges from the awareness of a situated living body as a sensorimotor unit that enables selfhood in the physical world in the «here and now» and is endowed with a sense of action, property, and first person non-conceptual content.



Yet, educational systems largely operate at the level of the Narrative Self, emphasizing external validation, role conformity and memorization. However, as emphasized by OECD, students need a broad range of skills, including cognitive and meta-cognitive skills (e.g. critical thinking, creative thinking, learning to learn and self-regulation); social and emotional skills (e.g. self-efficacy and collaboration); and practical and physical skills (Howells, 2018). In this context, cognitive flexibility and creativity are central and can emerge when students shift toward the Minimal Self, characterized also by heightened bodily awareness and empathy. This shift is facilitated through structured practices that engage body, mind, and emotion.

For example, recent studies underscore the link between interoception—the perception of internal bodily states—and social cognition, including empathy and emotional understanding. Marson *et al.* (2024) demonstrated that meditation and physical activity improve empathy by increasing bodily awareness and reducing supradiaphragmatic autonomic reactivity. Crucially, participants with higher bodily reactivity showed enhanced empathy when they embodied abstract concepts interoceptively, such as «freedom» or «justice.» In addition, a study by Stubbs *et al.* (2022) found that nearly 50% of individuals with severe asthma also exhibited symptoms of anxiety and/or depression. These psychological symptoms were significantly associated with dysfunctional breathing, dyspnoea, obesity, and reduced quality of life—despite similar pulmonary profiles across groups. Importantly, dysfunctional breathing and emotional distress appeared to reinforce one another, illustrating a bidirectional mind-body interaction. These findings support the argument that physiological states like respiration are closely modulated by emotional and cognitive processes, and that long-term well-being requires addressing both domains in tandem. Translating these insights into educational practice, body–mind interventions such as mindful movement or breathing-based practices may not only enhance learning and focus but also offer protective benefits for emotional and physiological health.

As we know, multisensory first-person experiences often help to illustrate scientific findings in a meaningful way. For example, recently, my mother—who served as both a school inspector for the Ministry of Education and a high school teacher—shared a powerful memory that still moves her today. Entering a classroom one morning, she watched as five students simultaneously pulled inhalers out of their pockets, struggling to manage their breathing. Having personally solved some respiratory problems through the consistent practice of yoga, which have been long known to be related with emotional and bodily imbalances (Stubbs *et al.*, 2022), she approached the school principal with a suggestion: to introduce yoga as part of the school's daily routine. The results, she later reflected, were nothing short of transformative. Students not only reported fewer asthma attacks, but teachers also observed improved focus, emotional regulation, and a

calmer classroom atmosphere. This lived experience mirrors the scientific understanding that physical and emotional well-being are deeply intertwined. Embodied practices like Yoga extend this insight into structured, scalable interventions. Grounded in the SMC, these methods help students develop the self-awareness, cognitive flexibility, and emotional balance necessary for creative learning. In what follows, we explore how such embodied approaches offer both a practical and theoretical foundation for cultivating whole-person development in educational contexts.

A recent meta-analysis by Wilkin, Allen-Baker, and Thornton (2024) examined whether school-based yoga interventions improve EFs in children aged 3–7. Drawing on data from seven studies with over 1,000 participants, the analysis found that yoga has a small but statistically significant positive effect on overall EFs, particularly enhancing working memory and inhibitory control, though evidence for cognitive flexibility remains insufficient. The impact was stronger for working memory than for inhibitory control. While the included studies varied in quality and detail, the findings suggest that yoga, which combines physical postures, breathing techniques, and meditation, offers a promising, enjoyable, and accessible intervention to support young children's self-regulation, attention, and cognitive development. Although the link to creativity was not directly assessed, these enhanced cognitive and emotional capacities are known precursors to creative thinking, suggesting that yoga may indirectly contribute to creativity by improving the underlying EFs necessary for idea generation, problem-solving, and adaptive learning. However, the authors emphasize the need for higher-quality, better-reported research to draw definitive conclusions and explore long-term and generalizable outcomes.

Caldarella and Moya's (2022) literature review synthesizes findings from 12 studies examining the benefits of yoga interventions in middle schools for students aged 10–15. The review highlights that school-based yoga programs consistently report positive outcomes across mental health, EFs, physical health, social interactions, and academic performance. Specifically, yoga has been shown to improve emotional regulation, self-esteem, stress management, memory, attention, and decision-making abilities. Programs also demonstrated reductions in anxiety, depression, anger, and behavioral issues, particularly among students identified as at-risk due to socioeconomic challenges or adverse life experiences. Additionally, some studies noted physical benefits such as improved flexibility and reduced waist circumference. Socially, yoga enhanced students' sense of belonging and cooperation, while academically, it supported increased engagement, reduced absenteeism, and improved grades. The review emphasizes that yoga is generally feasible to implement in diverse school settings, though program characteristics—such as timing, instructor qualifications, and cultural adaptations—require careful consideration. While findings are promising, the authors note variability in research design, yoga styles, and outcome measures, calling for more rigorous, longitudinal, and large-scale studies to solidify yoga's status as an evidence-based practice for school education. Future research should compare different contemplative modalities to evaluate their specific contributions to creativity and well-being, taking into consideration the underlying mechanisms in a systematic way.

Current Limitations in Educational Research and Policy

Across the body of research presented, a recurring limitation emerges: a lack of rigorous exploration of the underlying neural mechanisms driving the observed benefits of holistic physical activity interventions. While these studies compellingly advocate for addressing social, emotional, cognitive, and physical dimensions to optimize development and EFs, they primarily rely on behavioral, correlational, and theoretical arguments. Few studies directly investigate how these interventions engage, strengthen, or modify specific brain systems such as the prefrontal cortex or the neural circuits governing attention, cognitive flexibility, or emotional regulation. Moreover, most available research lacks the methodological rigor needed to draw causal inferences, particularly studies comparing real-world, meaningful activities with active control conditions, long-term follow-ups, and neural or biological outcome measures. Diamond (2018) specifically calls out the disproportionate focus on narrow, sterile interventions like computerized training or treadmill running, which may fail to generalize to real-life settings and overlook the integrative role of emotional engagement, social connection, and joy—factors known to modulate neural plasticity and EFs performance. The field urgently needs well-designed experimental research that not only tests whether such activities improve behavioral outcomes but also clarifies the neurobiological pathways involved, including how factors like stress, loneliness, or positive social interaction impact brain function and learning capacity. Without such evidence, educational policy and practice risk

continuing to marginalize these critical developmental supports, despite their historical and theoretical importance. Whether in music, sports, or as preparing the child to be a young entrepreneur or a brilliant therapist, educator or researcher, the child's flexible brain and positive neuroplasticity is possible. Many of these are based related to higher alpha activity. Which can be achieved through training.

As highlighted by Diamond, the field has disproportionately relied on correlational or retrospective studies, lacking robust experimental designs capable of establishing causality or identifying the biological pathways through which such interventions exert their effects. This has limited the ability of educators, policymakers, and funding agencies to prioritize these activities in educational settings with evidence-based confidence.

The Policy-Relevant Research Gap: Moving for learning

Despite growing evidence for embodied learning, educational policy lags behind due to gaps in experimental research and implementation models. Current intervention studies have tended to focus narrowly on isolated cognitive training or single-modality physical exercises (e.g., computerized cognitive tasks, aerobic running), often ignoring the interrelated physical, emotional, and cognitive dimensions of learning and development. Moreover, they rarely investigate the neural systems beyond cortical structures, leaving subcortical regions such as the cerebellum largely unexamined, despite its growing recognition as a critical hub for sensorimotor and cognitive integration (Ben-Soussan *et al.*, 2015). This gap presents a critical challenge for evidence-based education and health policy, particularly as schools increasingly deprioritize embodied and social activities in favor of narrowly defined academic instruction. Without rigorous, mechanistically informed research, policymakers lack the data necessary to justify investment in holistic, movement-based educational interventions. To address these gaps, we propose an integrated framework that builds on neuroscientific insights and embodied practices to foster whole-child development.

Having established the need for holistic interventions and their neural basis, we now turn to QMT as a structured example of such an approach. QMT offers a scientifically grounded response to this gap. As a whole-body, sensorimotor-cognitive training, QMT requires participants to perform spatial movements in response to unpredictable verbal commands, demanding attentional control, motor planning, and cognitive flexibility. Its structured, yet ecologically valid, design allows for controlled experimental manipulation, making it both a practical intervention and a model research paradigm for investigating embodied cognition. QMT is a sensorimotor training method developed to enhance creativity, EFs, and emotional regulation. Participants move in response to verbal instructions within a square grid, combining motor coordination, attention, and inhibition. The practice has been shown to increase EEG coherence, particularly in the alpha (10 Hz) and theta ranges, both associated with relaxed alertness, creative thinking, and creativity (for a review see De Fano *et al.*, 2019). Importantly the findings of a recent hyperscanning study demonstrate that better Math learning is linked to stronger theta-band brain synchrony with the whole class, while better Chinese language learning is linked to stronger alpha-band synchrony with top-performing peers, suggesting discipline-specific neural markers of effective learning (Chen *et al.*, 2023), which could in turn serve as a mechanism for additional groups effects, such as in the case of RNG (Radin, 1997).

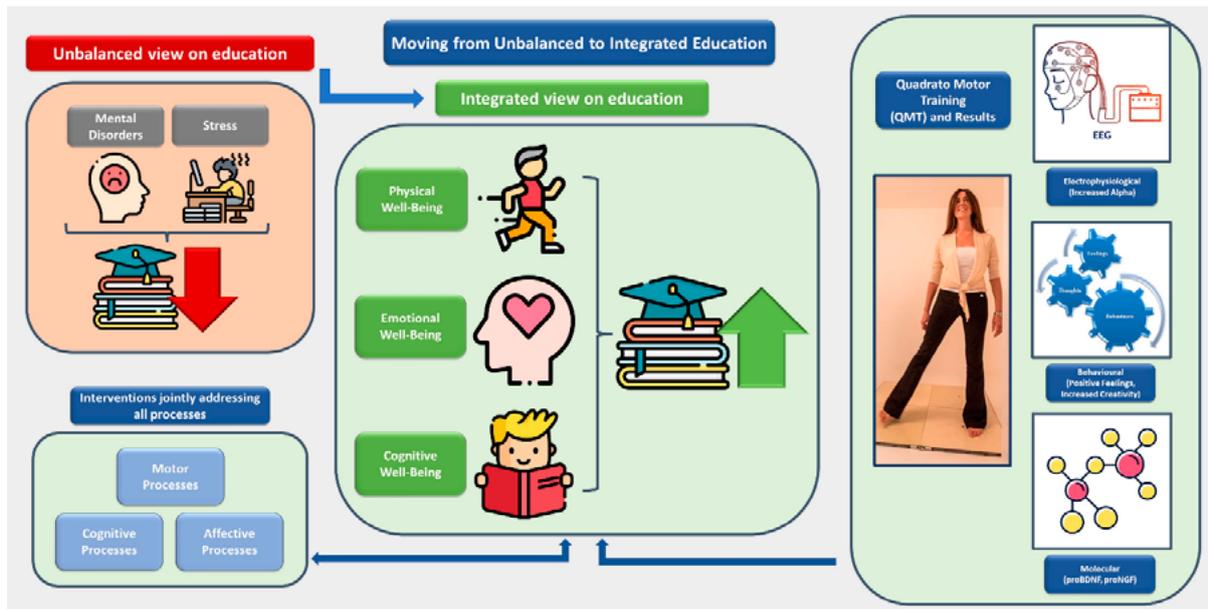
A Multilevel Mechanistic Framework

Consistent improvements in creativity, reading fluency, cognitive flexibility, and reflectivity have been demonstrated, suggesting broad applicability in both educational and clinical settings, empirical studies on QMT have advanced a multilevel model of cognitive improvement that integrates electrophysiological, molecular, and structural mechanisms. More specifically, QMT has been shown to: modulate cerebellar and frontal alpha oscillatory activity, enhancing functional connectivity that supports EFs, creativity, reading, and spatial awareness; decrease proNGF, markers linked to neuroplasticity and cognitive health (for a recent review see Paoletti *et al.*, 2023, Figure 3),

QMT research is especially suited to educational settings because it addresses multiple developmental needs simultaneously, namely: attention, emotional self-regulation, embodiment and neuroplasticity. Focusing on embodied practices and creativity in educational contexts, when comparing QMT and sitting meditation in elementary children, QMT was found to enhance cognitive flexibility and spatial cognition (Marson *et al.*, 2021). In addition, QMT-induced increased flexibility was negatively correlated with pro-nerve growth factor, a protein associated with stress and neurodegeneration (Venditti *et al.*, 2015).

Figure 3

From an unbalanced to an integrated view on education and the example of the QMT



Note. Adapted from Paoletti *et al.* (2023).

Educational policy and the role of neurotechnology

Building on the earlier discussion of alpha oscillations, which benefit academic performance and global wellbeing, we now explore how these mechanisms can be targeted through practical interventions, such as QMT and yoga. Neurotechnology, when used as a reflective tool rather than a distraction, can empower students to regulate their mental states in real time. The integration of EEG neurofeedback into learning routines represents a shift toward empowering students with real-time awareness of their cognitive-emotional states and how it can be regulated. Rather than viewing technology as inherently distracting, our project reframed it as a mirror for metacognition and creativity. This approach is scalable and cost-effective. EEG devices are increasingly affordable, and practices like yoga and QMT require minimal or no additional infrastructure. Teacher training modules are under development to support wider implementation across educational settings, including under-resourced schools.

Recently, we conducted an interdisciplinary workshop at a Montessori-inspired school. The program included a QMT session integrated into physical education and EEG wearable headband recording following visualization of brain states to students. Following the workshop, teachers reported that students became more curious about their own mental processes and more empathetic toward peers. In line with previous observations (Ben-Soussan *et al.*, 2019; Paoletti and Ben-Soussan, 2020). Silence was redefined as a creative and restorative space rather than a disciplinary void. While silence which often seen as punitive, can instead be reframed as a creative and reflective space that supports metacognitive awareness. These findings parallel shifts in neuroscience and education that recognize the value of rest, pause, and internal attention in cultivating learning and innovation. To advance both science and practice, greater investment is needed in rigorous, multidisciplinary studies that investigate embodied learning interventions like QMT and yoga. Such research holds the potential to shift educational and health policy toward whole-person development frameworks, integrating cognitive, motor, emotional, and social dimensions of learning. Policymakers and funding agencies should prioritize support for:

- Longitudinal intervention studies on embodied learning.
- Cross-sector partnerships between neuroscience, education, and public health.
- Scalable implementation models that bring scientifically validated practices into schools and communities.

This combined approach does not replace existing contemplative methods such as yoga, but expands the pedagogical toolkit by adding practices that are cognitively structured, neurologically informed, and easily adapted to various educational settings. Together, these methods allow educators to engage students across multiple dimensions of self-awareness—narrative, embodied, and transcendent—supporting the full spectrum of human potential. Our findings underscore the feasibility, accessibility, and impact of integrating structured contemplative movement into school curricula. QMT requires minimal resources, can be scaled across diverse settings, and are inclusive of students with varying needs and abilities. With EEG neurofeedback offering real-time insight into mental states, students begin to recognize the power of attention, stillness, and self-regulation in their learning journeys.

As education systems increasingly prioritize well-being, adaptability, and lifelong learning, these embodied practices represent more than classroom interventions—they signal a paradigmatic shift. By redefining silence, embodiment, and even technology as allies in the learning process, we can reimagine schools as environments where creativity is not a byproduct but a deliberate outcome. educational success in today's world requires moving beyond academics alone, integrating body, emotion, and mind to nurture the whole student's well-being and potential. In cultivating the creative brain through breath, movement, reflection, and neurocognitive insight, we not only equip students for academic success but also empower them as compassionate, resilient, and innovative contributors to a rapidly changing world.

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