DESIGNING HYBRID AND EMOTIONALLY AWARE LEARNING ENVIRONMENTS: THE CONTRIBUTION OF MULTISENSORY

Daniela Pasqualetto[1]
University of Enna "Kore"
daniela.pasqualetto@unikore.it

Alessandra Lo Piccolo
University of Enna "Kore"
alessandra.lopiccolo@unikore.it

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ABSTRACT
This study examines multisensory environments as hybrid, emotionally aware learning settings that promote psychophysical well-being and self-regulation in individuals with Special Educational Needs.
Drawing on embodied cognition, inclusive pedagogy and affective computing, it explores how sensory-rich environments function as adaptive educational systems supporting emotional and embodied experiences. The paper presents findings from a research and monitoring project conducted within the Chair of Special Pedagogy at the Kore University of Enna.
A multi-context observational design was implemented across three Snoezelen environments: two in primary schools and one in a socio-educational association for young adults with disabilities.
The findings highlight their potential to enhance participation, emotional regulation and autonomy, supporting the development of responsive and inclusive learning ecosystems across the lifespan.

KEYWORDS
Multisensoriality; self-regulation; emotional well-being; inclusion.

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1. Neurodiversity, special educational needs, and well-being in contemporary educational contexts

Over the past decades, the international educational landscape has undergone profound cultural, scientific, and pedagogical transformations that have progressively reshaped the interpretation of individual differences in learning processes. At the heart of this shift lies the paradigm of neurodiversity, a theoretical perspective that views cognitive, sensory, communicative, and emotional differences as natural expressions of human variability rather than deviations from a presumed developmental norm. This approach marks a departure from a long-standing educational and clinical tradition grounded in normalisation and the classification of differences according to predominantly deficit-oriented frameworks.

As Ferrari and Morandi (2020) argue, modern schooling emerged within a cultural paradigm deeply influenced by nineteenth-century positivism and classificatory medicine. Within this framework, children who deviated from expected cognitive, behavioural, or linguistic standards were regarded as departures from an ideal model of development. Diagnosis primarily served a selective function, and schools were conceived as institutions aimed at standardisation rather than at valuing diversity.

From the second half of the twentieth century onward, however, theoretical and legislative perspectives began to change substantially. Advances in developmental psychology, special pedagogy, and educational sciences challenged the rigid medicalization of learning difficulties (Trisciuzzi & Zappaterra, 2007). As Zappaterra (2010) points out, this transformation extends beyond school organisation and affects the entire cultural framework of education, opening the way to a new understanding of the relationship between individuals and their environments. Educational responsibility is no

longer attributed solely to students, who are expected to adapt to institutional standards; instead, it is increasingly shared by the educational system, which is called upon to rethink its organisational, methodological, and relational structures (Pavone, 2014).

Within this broader cultural shift, the paradigm of neurodiversity has gained increasing prominence. Initially emerging as an international movement advocating for the rights of autistic individuals, it has gradually expanded to encompass the full range of neurological and cognitive diversity within the population. According to Lo Piccolo and Pellerone (2020), the concept of neurodivergence makes it possible to move beyond pathologizing representations of cognitive differences by promoting an interpretation grounded in the recognition of individual characteristics and personal strengths. Neurodiversity does not deny the existence of difficulties or support needs; rather, it encourages their interpretation within a framework that values individual resources, cognitive styles, and diverse ways of learning (Lo Piccolo, 2021).

This perspective is particularly relevant for students with Specific Learning Disorders (SLD), Attention-Deficit/Hyperactivity Disorder (ADHD), Autism Spectrum Disorder (ASD), and other neurodevelopmental conditions. As Pecini and Brizzolara (2020) emphasize, these conditions cannot be fully understood solely through diagnostic categories, as they involve distinctive ways of processing information, perceiving the environment, and constructing social relationships. Inclusive schools are therefore called upon to recognise this diversity of functioning and to design flexible, personalised educational contexts capable of responding to students' different needs.

Within this theoretical framework, the concept of Special Educational Needs (SEN) assumes particular significance. The introduction of the SEN framework has broadened pedagogical reflection beyond clinical certification, acknowledging that difficulties in learning and participation may arise from multiple cognitive, emotional, relational, social, and cultural factors (Lo Piccolo & Pellerone, 2020). As Ianes (2022) argues, every learner embodies a form of "special normality", a concept that challenges the traditional distinction between "typical" and "special" students. This perspective highlights the need to design educational environments that embrace variability as an ordinary dimension of school life.

Recent pedagogical research has further emphasized that the quality of inclusion cannot be assessed solely in terms of curriculum accessibility or academic achievement. Increasing attention has been devoted to well-being as a fundamental dimension of educational experience. Confalonieri and Olivari (2022) argue that emotions, motivation, sense of belonging, and self-efficacy significantly influence learning processes and the development of school identity. Participation depends not only on students' cognitive abilities but also on the quality of relationships, perceptions of safety, and the opportunities provided by educational environments for self-expression.

This perspective is particularly relevant for neurodivergent learners, who frequently experience vulnerabilities in emotional and sensory self-regulation. Research on neurodevelopmental disorders suggests that behaviours traditionally viewed as problematic often represent adaptive responses to sensory or emotional overload (Confalonieri & Olivari, 2022). Environments characterised by excessive sensory stimulation, rigid organisation, or low predictability may generate chronic stress, thereby compromising attention, participation, and learning. From this perspective, educational difficulties are

understood not merely as individual characteristics but as the outcome of interactions between personal characteristics and inadequately designed environments.

Contemporary neuroscience provides strong evidence supporting this interpretation. Studies on brain plasticity and self-regulation demonstrate that learning, emotions, and the body are deeply interconnected. Attention, memory, motivation, and the capacity to deal with complex tasks are strongly influenced by emotional experience and perceived well-being. Neuroeducational perspectives therefore emphasise the importance of designing learning environments that promote psychological safety, active engagement, and emotional regulation (Cornoldi, 1995).

These findings converge with theories of embodied cognition, according to which knowledge emerges through continuous interaction between mind, body, and environment. Learning is not solely a cognitive process but an embodied experience involving perception, movement, emotions, and relationships (Peluso Cassese & Torregiani, 2017). From this perspective, well-being is not merely a favourable condition for learning but a structural component of educational processes. Consequently, schools are called upon to support not only cognitive development but also the bodily, sensory, and emotional dimensions of human experience.

Within this context, multisensory environments have attracted growing interest as educational settings capable of promoting well-being and self-regulation. Through the controlled modulation of visual, tactile, auditory, and proprioceptive stimuli, these environments provide opportunities for exploration, relaxation, emotional regulation, and bodily awareness that are particularly valuable for individuals experiencing difficulties in managing environmental stimuli (Bruno et al., 2010). Their increasing diffusion across

educational and rehabilitation contexts reflects a broader understanding of inclusion, one that places the quality of lived educational experience alongside access to learning opportunities.

In light of these considerations, well-being has become a strategic dimension of inclusive educational design. The contemporary challenge is not merely to guarantee learning opportunities for all students but to create educational ecosystems capable of fostering participation, emotional regulation, autonomy, and holistic human development. Within this perspective, neurodiversity should not be regarded as a condition requiring compensation but rather as a lens through which educational environments, practices, and relationships can be critically reimagined, paving the way for pedagogical models that value human diversity and promote well-being throughout the lifespan.

2. Snoezelen environments and sensory technologies: towards responsive educational ecosystems

Originally developed in the Netherlands during the 1970s by Jan Hulsegge and Ad Verheul (1987) as controlled sensory environments for individuals with intellectual disabilities, Snoezelen spaces were initially conceived as settings for relaxation and sensory stimulation. Over the past decades, however, their educational potential has progressively expanded, moving beyond therapeutic purposes to become learning environments that promote participation, emotional regulation, and personal development (Solomon & Botha, 2024). Rather than functioning solely as sensory rooms, contemporary Snoezelen environments are increasingly recognised as educational settings in which bodily experience, environmental interaction, and emotional engagement support meaningful learning processes.

This pedagogical evolution reflects broader developments in inclusive education. Contemporary perspectives no longer interpret multisensory environments as compensatory spaces designed to reduce individual deficits; instead, they are viewed as contexts that enable learners to explore, communicate, and actively construct meaning through multiple sensory modalities (Acevedo Bianca, 2021). Within this framework, visual, tactile, auditory, proprioceptive, and olfactory stimuli become educational mediators that foster embodied experiences. Consistent with theories of embodied cognition, learning emerges through the continuous interaction between body, mind, and environment, highlighting the inseparable relationship between cognitive processes and sensorimotor experience (Palmiero & Borsellino, 2018).

The educational value of Snoezelen environments appears particularly significant for learners with Special Educational Needs (SEN) and neurodivergent profiles. Individuals with Autism Spectrum Disorder (ASD), Attention-Deficit/Hyperactivity Disorder (ADHD), and Specific Learning Disorders frequently experience difficulties in sensory processing, emotional regulation, and behavioural control (Pecini & Brizzolara, 2020). In these cases, carefully designed multisensory environments provide predictable and controllable sensory experiences that facilitate emotional balance, improve attentional regulation, and support engagement in learning activities. Research on metacognition and self-regulation consistently emphasises that awareness of one's internal states and the development of effective emotional regulation strategies constitute essential conditions for learning (Cornoldi, 1995; Ianes, 2001a). Snoezelen environments appear particularly suited to supporting these processes by creating educational experiences in which sensory regulation precedes and facilitates cognitive engagement.

Recent technological developments have further transformed the educational potential of multisensory environments. Intelligent lighting systems, immersive projections, motion sensors, interactive devices, and adaptive software have progressively converted traditional Snoezelen rooms into dynamic learning environments capable of responding to users' behaviours and needs (D'Agostini, 2022). Consequently, the environment becomes an active educational partner rather than a passive setting, continuously adapting sensory stimulation through changes in lighting, sound, colour, and spatial configuration. This shift marks the transition from static multisensory rooms to responsive educational ecosystems in which technology personalises educational experiences while preserving the centrality of human relationships.

These developments also establish important connections with the field of affective computing, introduced by Rosalind Picard (1997), which investigates technological systems capable of recognising and responding to human emotional states through physiological and behavioural indicators. Although the educational application of these technologies continues to raise ethical and pedagogical questions, they offer promising opportunities for designing responsive learning environments. Within educational contexts, intelligent sensory systems could identify signs of stress or sensory overload and dynamically adjust environmental conditions to support emotional regulation. Nevertheless, such technologies should be understood as tools that enhance educational mediation rather than replace the intentional role of educators.

From this perspective, the educational value of sensory technologies lies not in technological innovation itself but in their capacity to expand opportunities for participation, communication, autonomy, and self-determination. Contemporary Snoezelen environments can therefore be interpreted as

responsive educational ecosystems in which pedagogical intentionality, sensory technologies, embodied experience, and human relationships converge to promote well-being, self-regulation, and inclusive participation.

3. Research design and empirical evidence in multisensory contexts

To explore the role of multisensory environments in promoting well-being, self-regulation, and inclusion, an observational study was conducted within the research activities of the Chair of Special Pedagogy at the KoreUniversity of Enna. The study adopted an exploratory, descriptive-interpretative qualitative multiple-case design based on systematic non-participant observation across three different Snoezelen environments. Rather than focusing on the standardised measurement of predefined variables, the study sought to examine the meanings of participants' experiences and their individual responses to multisensory educational settings.

Data were collected through six observation sessions, each lasting between 30 and 35 minutes. The six sessions were distributed equally across the three contexts, with two sessions conducted in each setting. In Caltagirone, the same three pupils with Special Educational Needs and three typically developing peers involved in peer-support activities participated in both observation sessions. In Valverde, the same three pupils with Special Educational Needs were observed in both sessions. In Riesi, the same two young adults were observed in both sessions. Participants were different across the three settings; thus, repeated observation concerned the same participants within each context only. The sessions included both structured educational activities and periods of free exploration, allowing participants to interact spontaneously with the multisensory environment. The children and young adults involved presented certified diagnoses and heterogeneous clinical and educational

profiles, making it possible to document a wide range of behaviours, interactions, and regulatory strategies. Accordingly, the sample was not intended to achieve statistical representativeness but to provide an in-depth understanding of educational processes within naturally occurring contexts. This methodological approach is consistent with the qualitative tradition in educational research, which privileges the interpretation of meanings and lived experiences over the quantitative measurement of phenomena (Mantovani, 1998).

Systematic non-participant observation was selected as the primary data collection strategy in order to document participants' interactions with sensory stimuli and with others in a rigorous yet minimally intrusive manner. The focus was placed not only on educational outcomes but also on the processes unfolding throughout the multisensory experience.

The study was conducted across three multisensory environments selected through purposive sampling to maximise contextual variation while maintaining a common pedagogical reference to the Snoezelen approach. This sampling strategy enabled comparison across different organisational settings, age groups, and educational purposes.

The first setting was the multisensory room at the *Alessio Narbone Comprehensive School* in Caltagirone, established in 2016 and among the earliest school-based Snoezelen environments in Sicily. It includes a sensory entrance corridor, decompression areas, and equipment specifically designed to promote emotional and sensory regulation. The second setting was the multisensory environment at the *Padre Gabriele Maria Allegra Comprehensive School* in Valverde, inaugurated in 2024 and characterised by an advanced technological infrastructure including a vibroacoustic pool, sensory tunnel, black room, and immersive interactive systems. The third setting consisted of a

multisensory environment established in 2025 within a socio-educational association in Riesi, serving young adults with intellectual disabilities and neurodevelopmental conditions. Activities in this context primarily focused on fostering personal autonomy, social participation, and relational well-being.

Data were collected using a structured observational checklist specifically developed for the purposes of the present study. The instrument included five observational domains: (a) use of multisensory equipment; (b) communicative behaviours; (c) emotional and bodily self-regulation; (d) quality of social interactions; and (e) participation in educational activities. Structured observations were complemented by descriptive field notes, enabling the integration of systematic behavioural indicators with contextual and interpretative information.

Across the two school settings, six pupils with different neurodivergent profiles—including autism spectrum disorder (both low- and high-functioning), attention-deficit/hyperactivity disorder (ADHD), DiGeorge syndrome, and mild intellectual disability—were observed. At the Alessio Narbone Comprehensive School in Caltagirone, three typically developing peers also participated in both sessions as part of peer-support activities, allowing the exploration of inclusive interactional dynamics. In the community-based setting in Riesi, two young adults with different disabilities participated in activities aimed at promoting personal autonomy, social participation, and relational competence. As specified above, the same participants within each setting were observed in both sessions, whereas the participant groups differed across the three contexts.The main characteristics of the three educational settings are summarised in Table 1, highlighting the diversity of organisational

configurations, participant characteristics, and educational aims that informed the comparative analysis of the different implementations of the Snoezelen approach.

Table 1. Characteristics of the three observed settings and the main features of the research design.

Setting	Participants	Age / Educational Level	Primary Educational Focus	Main Multisensory Features
IC "Alessio Narbone", Caltagirone (Italy)	3 pupils with Special Educational Needs (ASD, ADHD, DiGeorge syndrome) and 3 typically developing peers involved in peer-support activities; the same 6 participants were observed in both sessions	Primary school	Emotional self-regulation, school inclusion, and learning support	Sensory corridor, Nordic Relax Chair, interactive tatami, optical fibres, bubble column, tactile panels
IC "Padre G. M. Allegra", Valverde (Italy)	3 pupils with SEN (ASD and mild intellectual disability); the same 3 participants were observed in both sessions	Primary school	Sensory regulation, participation, and relational skills	Vibroacoustic pool, black room, sensory tunnel, immersive projections, interactive lighting systems
Socio-educational Association, Riesi (Italy)	2 young adults with intellectual disabilities and neurodevelopmental disorders; the same 2 participants were observed in both sessions	19–40 years	Personal autonomy, social participation, and relational well-being	Vibroacoustic equipment, optical fibres, tactile panels, bubble tube

The comparative analysis of the observational data documented recurring behaviours associated with emotional and sensory self-regulation across the three settings, together with context-specific patterns related to organisational characteristics, educational purposes, and participants' profiles. Given the exploratory qualitative design and the two observation sessions conducted in each context, these findings are interpreted as patterns documented during the observed sessions rather than as evidence of effects produced by multisensory environments or of stable changes over time.

The first key finding concerns behaviours associated with emotional and sensory self-regulation. Across the observation sessions, participants were observed engaging voluntarily with the multisensory environments, remaining within the activities, and exploring the available spaces. In several observations, avoidance behaviours and signs of hyperarousal were less evident during engagement with selected sensory resources. Among participants experiencing greater difficulties in sensory regulation, the observational records documented tolerance of sensory stimuli and continuity of participation during the educational activities. These observations describe behaviours occurring within the sessions and should not be interpreted as evidence of a progressive change over time.

The observations also revealed differentiated patterns in the use of multisensory technologies according to individual needs. Vibroacoustic devices, fibre optics, tactile surfaces, deep-pressure equipment, and proprioceptive resources were the most frequently used during the educational sessions. Among participants with autism presenting higher support needs, engagement with these resources was observed alongside sustained attention, episodes of eye contact, and periods in which disorganised

behaviours were not evident. In the community-based setting, the young adults autonomously selected multisensory resources during the observed activities and used them as personal means of sensory and emotional regulation.

A second major finding concerns the relational dimension of the multisensory experience. In both school settings, spontaneous peer interactions, participation in shared activities, and episodes in which continuous adult mediation was not required were documented during the observations. Peer-support activities provided occasions for collaboration, reciprocity, and mutual recognition within the multisensory setting. Related interactional patterns were also documented in the community-based setting, where participants shared sensory experiences and engaged in group activities.

Finally, the comparative analysis highlighted several distinctive features across the three settings. In Caltagirone, the observations documented use of the organised sensory pathway and engagement in activities oriented towards emotional regulation and relaxation. In Valverde, the more advanced technological infrastructure provided a wider range of exploratory and motivational opportunities and required educators to adapt activities to participants' different sensory profiles. In the community-based setting in Riesi, the observations documented autonomous choices of sensory resources, participation in shared activities, and behaviours related to self-determination and personal autonomy among the young adults involved.

Table 2. Main findings emerging from the comparative analysis of the three multisensory settings.

Observed Dimension	IC "Alessio Narbone", Caltagirone (Italy)	IC "Padre G. M. Allegra", Valverde (Italy)	Socio-educational Association, Riesi (Italy)
Self-regulation	Reduced hyperactivation and longer voluntary engagement within the environment	Sensory regulation behaviours and sustained attention during selected activities	Autonomous use of multisensory resources as self-regulation strategies
Participation	Engagement in individual and small-group activities	Participation in structured educational activities	Voluntary participation in educational activities
Relationships	More frequent interactions with peers and teachers	Strengthened communication with educators and classmates	Sharing of sensory experiences during group activities
Autonomy	Initiative in exploring environment	Independent selection of sensory devices	Autonomous choice of sensory resources and self-management of activity duration
Well-being	Periods in which avoidance behaviours were not evident during engagement	Greater relaxation during educational activities	Voluntary engagement, autonomous choice of sensory resources, and sustained presence within the environment

Overall, the findings summarised in Table 2 document behaviours associated with self-regulation, participation, and well-being during the observed Snoezelen activities. Rather than demonstrating that the environments produced these outcomes, the observations indicate how such dimensions were expressed within the specific sessions and contexts examined. The recurring patterns identified across the three settings provide an empirical foundation for the subsequent discussion of the pedagogical implications, offering valuable insights for the design of increasingly inclusive and responsive learning environments.

4. Discussion of emerging evidence and implications for inclusive educational design

The findings emerging from the comparative analysis of the three multisensory settings suggest that Snoezelen environments promote self-regulation, participation, and well-being, extending their educational role beyond traditional sensory support and relaxation. This interpretation is consistent with contemporary perspectives in special pedagogy, which conceptualise inclusion not as a static condition or a set of accommodations for specific groups of learners, but as a dynamic process of designing educational contexts capable of responding to the diversity of human functioning (Ianes, 2022; Pavone, 2014). From this perspective, the educational environment becomes an active mediator that shapes opportunities for participation, learning, and personal development.

A particularly significant aspect concerns the relationship between multisensory experiences and self-regulation. Research in educational neuroscience and developmental psychology consistently demonstrates that the ability to regulate emotions, attention, and behaviour is fundamental for learning and social participation (Pecini & Brizzolara, 2020). Likewise, studies on metacognition emphasise that self-regulation is not solely a cognitive competence but involves bodily, emotional, and relational dimensions that develop through continuous interaction with the environment (Cornoldi, 1995; Ianes, 2001b). Within this framework, Snoezelen environments appear particularly well suited to fostering bodily awareness, sensory modulation, and emotional regulation, thereby creating favourable conditions for the development of self-regulatory competences.

The findings are also consistent with the theoretical perspective of embodied cognition, according to which cognitive processes emerge through the continuous interaction between mind, body, and environment (Palmiero & Borsellino, 2018). Learning cannot therefore be understood as a purely mental activity but as an embodied process deeply rooted in sensorimotor experience and social interaction. From this perspective, multisensory environments acquire significant pedagogical value because they integrate perception, movement, emotion, and cognition into a unified educational experience. Sensory stimulation is not merely a support for learning but becomes an integral component of the processes through which individuals construct meaning, develop competences, and participate in social life.

Another important implication concerns the relationship between inclusion and well-being. Contemporary quality-of-life frameworks identify emotional well-being, self-determination, interpersonal relationships, and social participation as fundamental dimensions of human development (Schalock et al., 2021). Within this theoretical perspective, multisensory environments can be interpreted as educational settings that promote not only access to learning opportunities but also the conditions necessary for individuals to express their potential and participate meaningfully in everyday life. This is particularly relevant for learners with neurodivergent profiles and Special Educational Needs, for whom well-being frequently represents a prerequisite for learning and social inclusion (Confalonieri & Olivari, 2022; Lo Piccolo & Pellerone, 2020).

The present findings also encourage reflection on the role of educational space in contemporary pedagogical design. As Weyland (2018) argues, learning environments are not passive containers of educational activities but active agents that influence behaviour, relationships, and learning processes. Similarly, Vanacore and Gomez Paloma (2020) emphasise that inclusive

educational spaces should be designed by considering the bodily, emotional, and sensory dimensions of human experience. From this perspective, Snoezelen environments represent meaningful examples of learner-centred educational design, capable of providing differentiated opportunities for access, participation, and well-being.

Finally, the findings support the interpretation of multisensory environments as emerging forms of responsive educational ecosystems. Advances in immersive technologies, intelligent sensory systems, and affective computing open new possibilities for designing educational environments capable of dynamically adapting to learners' characteristics and needs (Picard, 1997). Although these developments require continuous ethical and pedagogical reflection, they also offer opportunities to move beyond standardised educational models towards increasingly personalised and flexible learning environments. Technological innovation, however, acquires educational value only when guided by clear pedagogical intentionality and an inclusive vision of the learner. The challenge is therefore not to automate educational processes but to integrate technology and human relationships in ways that promote participation, self-determination, and quality of life (Muscarà, 2018).

The findings of this study should be interpreted in light of several limitations. The qualitative nature of the research, the small number of participants, the two observation sessions conducted in each setting, and the specificity of the observed contexts do not allow statistical generalisation or causal attribution. Repeated observation of the same participants within each context made it possible to document recurring patterns across the two sessions, but it does not establish developmental trajectories or stable changes over time.

Nevertheless, the observational data provide contextually grounded insights into behaviours occurring within multisensory educational activities and support the need for further longitudinal and multi-site research.

Overall, the three multisensory settings examined in this study offer useful contexts for reflecting on the relationship between special pedagogy, technological innovation, and inclusive educational design. The observations documented interconnections among behaviours related to well-being, participation, self-regulation, and autonomy within the specific sessions analysed. In this perspective, Snoezelen-inspired multisensory environments warrant further investigation as possible components of responsive educational ecosystems capable of recognising diversity and supporting inclusive participation across different stages of life.

Future research should further investigate the integration of multisensory environments with artificial intelligence–based adaptive technologies and non-invasive systems for monitoring emotional states. Longitudinal and mixed-method studies will be essential for evaluating their educational effectiveness and for developing responsive educational ecosystems in which technology enhances, rather than replaces, pedagogical mediation.

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