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SENSORY GARDENS AS A STRATEGY FOR INCLUSIVE ENVIRONMENTAL EDUCATION

JARDINS SENSORIAIS COMO ESTRATÉGIA PARA EDUCAÇÃO AMBIENTAL INCLUSIVA

JARDINES SENSORIALES COMO ESTRATEGIA DE EDUCACIÓN AMBIENTAL INCLUSIVA

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Abstract
Environmental Education is a key strategy in preparing conscious citizens to face socio-environmental challenges. In the school context, it promotes environmental awareness and collaborative learning, through implementing pedagogical practices that address the diverse abilities and needs of students remains a challenge. In this regard, sensory gardens emerge as an innovative approach that integrates Environmental Education and inclusion through practical, multisensory experiences. This study, a bibliographic review based on searches in ScienceDirect, SciELO, and Google Scholar, aimed to analyze the pedagogical and social impacts of sensory gardens in promoting inclusive Environmental Education, focusing on three main axes: pedagogical and social benefits, inclusive practices, and effectiveness of sensory elements. From the initial 28,100 results in Google Scholar and 410 in ScienceDirect, only nine studies were retained after successive filtering for critical synthesis, while SciELO yielded no results. The findings show that sensory gardens are effective pedagogical tools that integrate students with diverse needs, support accessible educational experiences, promote sustainability, and contribute to collective well-being, reinforcing inclusive educational practices, the development of socio-emotional and cognitive skills, and ensuring equitable learning opportunities within the school context.

Keywords: Educational tools. Sensory integration. Environmental. Awareness.

Resumo
A Educação Ambiental constitui-se como uma estratégia para a formação de cidadãos conscientes e capacitados para enfrentar os desafios socioambientais. No contexto escolar, promove a sensibilização ambiental e o aprendizado colaborativo. Entretanto, a adoção de práticas pedagógicas que contemplem a diversidade de habilidades e necessidades dos

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alunos permanece um desafio. Nesse sentido, os jardins sensoriais destacam-se como uma abordagem inovadora, unindo Educação Ambiental e inclusão através de experiências práticas que estimulam e fortalecem os sentidos. Assim, o estudo teve como objetivo analisar os impactos pedagógicos e sociais dos jardins sensoriais na promoção de uma Educação Ambiental inclusiva. Trata-se de uma revisão bibliográfica baseada em buscas nas bases *ScienceDirect, SciELO* e Google Acadêmico, com foco em três eixos: benefícios pedagógicos e sociais, práticas inclusivas e eficácia dos elementos sensoriais. O levantamento inicial identificou 28.100 estudos no Google Acadêmico e 410 no *ScienceDirect.* Apenas nove estudos foram selecionados após filtragens sucessivas para a síntese crítica. A base *SciELO* não apresentou resultados. Os dados evidenciam a escassez de pesquisas diretamente relacionadas à temática. Os resultados evidenciam que os jardins sensoriais são ferramentas pedagógicas práticas, integrando alunos com diferentes necessidades e promovendo experiências educativas acessíveis, além de incentivar a sustentabilidade, como espaços históricos para o bem-estar coletivo fortalecendo as práticas educativas inclusivas. Ao promover a aprendizagem experiencial, os jardins sensoriais levam à conscientização ambiental, ao desenvolvimento de habilidades socioemocionais e cognitivas, além de garantir oportunidades equitativas de aprendizagem para todos os alunos. Assim, é um importante recurso para uma formação integral no contexto escolar.

Palavras-chave: Ferramentas educacionais. Integração sensorial. Conscientização. Ambiental.

Resumen
La Educación Ambiental representa una estrategia clave para la formación de ciudadanos conscientes y preparados frente a los desafíos socioambientales. En el contexto escolar, favorece la sensibilización ambiental y el aprendizaje colaborativo, aunque la implementación de prácticas pedagógicas que atiendan a la diversidad de habilidades y necesidades estudiantiles aún representa un reto. En este sentido, los jardines sensoriales surgen como una propuesta innovadora que articula Educación Ambiental e inclusión mediante experiencias prácticas que estimulan los sentidos. Este estudio, basado en una revisión bibliográfica realizada en las bases ScienceDirect, SciELO y Google Académico, tuvo como objetivo analizar los impactos pedagógicos y sociales de los jardines sensoriales en una Educación Ambiental inclusiva, considerando tres ejes: beneficios pedagógicos y sociales, prácticas inclusivas y eficacia de los elementos sensoriales. De los 28.100 estudios identificados inicialmente en Google Académico y 410 en ScienceDirect, solo nueve fueron seleccionados tras filtros sucesivos filtros para la síntesis crítica; SciELO no presentó resultados. Los hallazgos indican que los jardines sensoriales actúan como herramientas pedagógicas efectivas, capaces de integrar estudiantes con diferentes necesidades, promover experiencias educativas accesibles, fomentar la sostenibilidad y contribuir al bienestar colectivo, fortaleciendo así las prácticas educativas inclusivas, el desarrollo de habilidades socioemocionales y cognitivas, y garantizando oportunidades equitativas de aprendizaje en el contexto escolar.

Palabras clave: Herramientas educativas. Integración sensorial. Concienciación. Ambiental.

1 Introduction

Environmental Education has increasingly established itself as a topic of growing relevance, drawing the attention of society, which recognizes its great

potential to foster a new socio-environmental awareness. In acknowledgement of its importance, various social sectors have been committed to implementing and practicing this educational approach, with particular emphasis on the school environment (Bagnolo, 2010).

Moreover, Environmental Education fosters the development of both affective and cognitive abilities, allowing for a broader and more critical interpretation of the world from an environmental perspective. In this sense, it serves as a mediating tool that facilitates multiple understandings of individual and collective experiences in their interactions with the environment, emerging as a direct response to society's growing concerns regarding the future of life on the planet (Silva *et al.*, 2020).

When applied to both inclusive and non-inclusive pedagogical practices, Environmental Education faces challenges due to the diversity of students' abilities and needs. Overcoming these obstacles requires awareness and preparation by educators to adopt inclusive approaches that respect the realities and limitations of their students. The traditional model, focused on expository teaching and individualized tasks, must be restructured to promote an education that embraces diversity, as it does not meet the necessary requirements to ensure the full participation of all students (Mantoan, 2003; Matos *et al.*, 2024).

The use of technologies, platforms, applications, educational games, and other interactive tools has become essential in current educational context. When appropriately employed, these tools can contribute not only to environmental awareness but also to the enhancement of various educational areas, offering potential solutions to the challenges and conflicts encountered in pedagogical practice. Through Environmental Education, it is possible to foster the development of environmental awareness that sparks student interest in environmental preservation and is constructed collaboratively (Cuba, 2010; Souza Dimas; Novaes; Avelar, 2021).

Among these resources, sensory gardens stand out as an alternative tool. These are defined as environments that promote relaxation and gently stimulate the senses, providing a safe and comfortable space for individuals with various disabilities - such as visual impairments, deaf blindness, motor impairments affecting

gait, cognitive and balance disorders - as well as children with autism and other sensory processing disorders, allowing them to explore sensory perceptions without being overwhelmed (Worden; Moore, 2004; Corrêa, 2009; Romani; de Araújo; Barbosa, 2021).

For neurotypical individuals, sensory gardens also offer a rich educational experience, allowing for the exploration and understanding of the senses through interaction with nature. In these spaces, visitors are encouraged to touch, smell, taste, and interact with their surroundings, promoting a sense of respect and responsibility towards nature. The aim is for these spaces to be established as sustainable environments, offering a sensory experience that contributes to both individual and collective well-being, while also fostering sustainability awareness (Romani; de Araújo; Barbosa, 2021).

Students with and without special needs often face barriers that hinder their active participation, while traditional pedagogical approaches fail to fully address the diversity of abilities present in classrooms. Sensory gardens, as pedagogical tools, have the potential to overcome these limitations by offering practical and accessible experiences that stimulate the senses and promote inclusion. However, there is limited information on the impacts of this approach on the learning outcomes of students with and without special needs in the context of Environmental Education. Based on this, the following guiding question emerges: To what extent do sensory gardens contribute to the promotion of inclusive Environmental Education in the school context, considering their pedagogical and social impacts?

Thus, this study aims to analyze the pedagogical and social impacts of sensory gardens, with an emphasis on their applicability within the context of Inclusive Environmental Education. The relevance of this research lies in the growing demand for educational practices that promote both inclusion and sustainability.

2 Methodology

A bibliographical search was conducted using three widely recognized academic databases: ScienceDirect (https://www.sciencedirect.com), SciELO (https://www.scielo.br/), and Google Scholar (https://scholar.google.com.br/?hl=pt),

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with the aim of ensuring the relevance and reliability of the sources. The search was performed using English keywords such as "sensory gardens AND inclusive environmental education" to broaden the scope and avoid language restrictions, considering that English is widely used in scientific publications. The keywords were selected to guide the search toward studies aligned with the research objectives. The publications found were compiled into a bibliographic collection, with duplicate entries removed. An initial screening was then carried out by reading titles and abstracts. To ensure the contemporaneity of the evidence, a filter was applied to include only studies published within the last ten years (from 2014 to 2024). The study followed the steps presented in Figure 1.

Figure 1 – Description of the steps followed for the development and clarification of the study.

Source: Prepared by the authors (2024)

Specific inclusion and exclusion criteria were defined for the selection of articles. The inclusion criteria encompassed studies published within the last ten years that addressed the use of sensory gardens in educational contexts, with an emphasis on inclusion and environmental education. Broader studies were also considered, provided they included elements related to educational practices. The exclusion criteria involved articles with a predominantly technical focus that did not present an applied approach to educational settings, as well as studies that did not consider the inclusion of students. Gray literature, such as book chapters and

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technical notes, was also excluded from the review. To ensure the relevance of the selected works, filters were applied to assess compatibility with the research objectives, eliminating materials that did not meet the established criteria.

The collected data were organized using Zotero® software, which allowed for efficient systematization and categorization of bibliographic references. After selection, the articles underwent a critical analysis, considering their contributions in terms of presented results, effectiveness, benefits, and applicability within the context of sensory gardens. For the organization and screening of the studies, a Microsoft Excel® spreadsheet was used, containing detailed information such as title, authors, year of publication, journal, source database, and main findings of each study.

3 Results and Discussion

3.1 Bibliometric Analysis

Based on the filtering and selection process of studies from three databases - Google Scholar, ScienceDirect, and SciELO - Google Scholar yielded the highest number of results, totaling 28,100 studies, followed by ScienceDirect with 410, while SciELO did not return any initial results. After filtering out irrelevant materials by type, the number of articles was reduced to 2,540 on Google Scholar and 263 on ScienceDirect. Applying a time filter for the past ten years resulted in 1,890 studies on Google Scholar and 215 on ScienceDirect, highlighting a more restricted temporal focus across the analyzed databases.

A subsequent screening, which excluded studies unrelated to the research theme, narrowed the results down to 41 studies on Google Scholar and eight on ScienceDirect. Title and abstract screening further reduced the number of studies to 13 from Google Scholar and eight from ScienceDirect (n = 21 total), as many articles addressed the topic but in contexts unrelated to education. Finally, for the critical synthesis phase, eight studies from Google Scholar and one from ScienceDirect remained (Figure 2). It is important to note that the SciELO database did not yield

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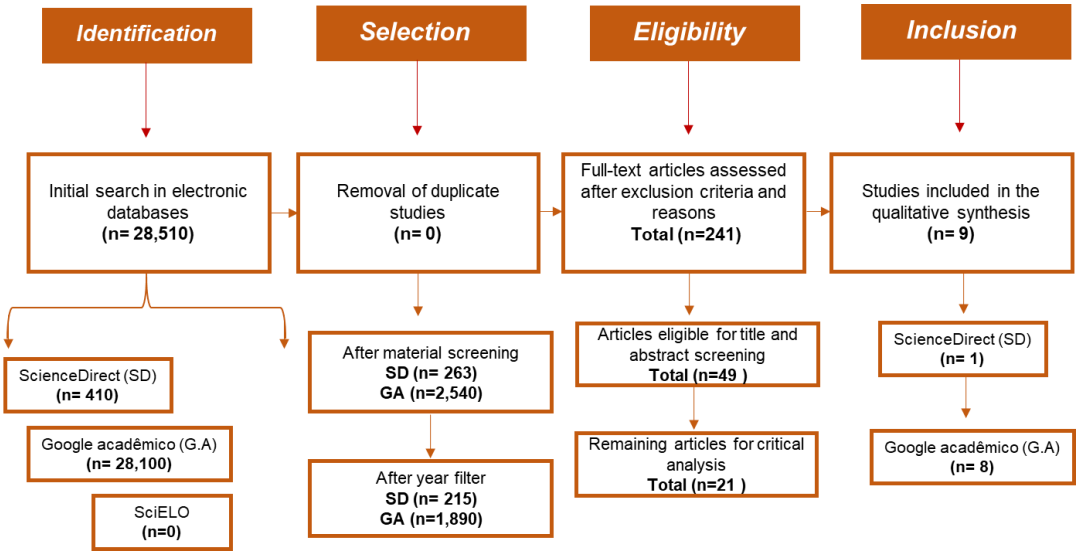
any results during any of the screening phases. Thus, the filtering process significantly reduced the number of studies, ensuring the selection of materials that were relevant and aligned with the research theme.

Figure 2 – Diagram of the systematic mapping of studies across three databases: Google Scholar, ScienceDirect, and SciELO.



Source: Prepared by the authors (2024)

In the layout of Table 1, an analysis of the journals, publication years, and authors is presented, allowing the identification of important trends regarding the development and dissemination of knowledge on the topic of sensory gardens and pedagogical inclusion. The publication period of the selected articles ranged from 2016 to 2024, in line with the proposed ten-year timeframe (2014–2024).

Table 1 – Main studies considered for the critical synthesis evaluation on the topic of Sensory Gardens.

No.	Author(s)	Title	Year	Journal
1	Caiola *et al.*	Designing integrated physical–digital systems for children–nature interaction	2023	International Journal of Child-Computer Interaction
2	Carrasco-Dionisio; Santos	Jardim sensorial – uma proposta de atividade pedagógica como ferramenta de educação ambiental	2016	Revista Unifev: Ciência & Tecnologia
3	Carvalho	O uso do jardim sensorial como ferramenta pedagógica na inclusão de alunos com TDAH	2022	Revista Ibero-Americana de Humanidades, Ciências e Educação

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4	Correira; Ramos, R.	Promoting sustainability: Environmental education activities in a social institution	2024	Interdisciplinary Journal of Environmental and Science Education
5	Fangwi; Tchombe.	Stakeholders' Perspective of Nature Expo Therapy on the Enhancement of Sensory Integration Ability of Children with Autistic Spectrum Disorders	2024	European Journal of Special Education Research
6	Ghazali *et al*.	Creating positive environment for autism using sensory design	2019	Environment-Behaviour Proceedings Journal
7	Queiroz *et al*.	Jardim sensorial numa escola do campo: uma ferramenta para o ensino de ciências	2022	Revista Macambira
8	Salsabila,; Muna	Analysis of Nature-Based-Learning for Children with Autism Spectrum Disorder in Elementary School Age: A Systematic Review	2023	Special and Inclusive Education Journal (SPECIAL)
9	Santos; Marafon	Contribuições sobre o jardim sensorial como alternativa pedagógica para o ensino e aprendizagem em espaços externos	2024	Ensino e Tecnologia em Revista

Source: Prepared by the authors (2024)

The analyzed works were obtained through searches in three academic databases, of which only Google Scholar and ScienceDirect yielded studies aligned with the scope of the research. This highlights a still limited, yet relevant, scientific production on sensory gardens and pedagogical inclusion. Specifically, only Article No. 1 was identified in the ScienceDirect database, while Articles No. 2 to 9 originated from Google Scholar. Furthermore, a high number of exclusions were observed in both databases, primarily due to many studies not being directly aligned with the thematic focus. This outcome underscores that, despite the rigorous application of keywords and inclusion criteria, both databases present a broad range of topics that do not always fit the parameters established for the study.

Unlike databases such as Web of Science and Scopus, Google Scholar is a free tool that retrieves various types of academic works, including articles, theses, and dissertations, in multiple languages. In addition to facilitating access to scientific publications, it allows the tracking of citation frequency, providing insight into the impact of research (Caregnato, 2011). However, despite its utility in the humanities and social sciences, its limitations in coverage and consistency require caution, as

they may lead to distorted results or even compromise the validity of the conclusions (Frandsen; Nicolaisen, 2008; Caregnato, 2011).

Although ScienceDirect hosts a robust database with approximately 12 million scientific articles, 2,200 journals, and 26,000 books - with its data also indexed in Scopus (Louzada-Junior, 2014) - the present study revealed a scarcity of results specifically related to the thematic objective investigated.

Among the analyzed articles, the year 2024 accounted for three publications (33.3%), followed by 2023 and 2022 with two publications each (22.2%), and 2019 and 2016 with one publication each (11.1%). The analysis of journals revealed a multidisciplinary range of sources, with emphasis on two classified as A1 (International Journal of Child-Computer Interaction and Journal of Environmental and Science Education), representing 22.2% of the publications. Another 11.1% appeared in B1-ranked journals (European Journal of Special Education Research and Revista Macambira). Journals classified as B3 (Revista Ibero-Americana de Humanidades, Ciências e Educação) and C (Ensino e Tecnologia em Revista) were also identified, each representing 11.1% of the publications (Table 2).

These classifications refer to the Qualis/CAPES system used in Brazil to classify scientific output, based on criteria such as journal impact, relevance, and indexing (Plataforma Sucupira, 2025). However, this system has been progressively revised and, in some fields, is being replaced by international metrics for editorial impact and relevance.

It was noted that 33.3% of the journals analyzed had no registered classification within the Qualis system, which may indicate either a lack of evaluation or a recent evaluation. The overall distribution shows a predominance of well-ranked journals but also highlights the need for more information regarding the unclassified ones.

Table 2 – Characterization of the studies by journals and their respective impact factors.

Journal	Qualis Rating	Occurrence
International Journal of Child-Computer Interaction	A1	1
Interdisciplinary Journal of Environmental and Science Education	A1	1
European Journal of Special Education Research	B1	1

Environment-Behaviour Proceedings Journal	-	1
Revista Unifev: Ciência & Tecnologia	-	1
Revista Ibero-Americana de Humanidades, Ciências e Educação	B3	1
Revista Macambira	B1	1
Ensino e Tecnologia em Revista	C	1
Special and Inclusive Education Journal (SPECIAL)	-	1

Source: Prepared by the authors (2024)

The impact factor, originally developed to measure the influence of scientific journals, has evolved to also assess the individual productivity of authors. This index is used in the evaluation of researchers by ranking their publications according to journals with varying levels of impact. Although widely accepted, there is a general consensus that the impact factor is not a perfect metric for assessing the quality of articles or the scientific output of authors. Nevertheless, due to the lack of more effective alternatives, it remains a relevant tool in scientific evaluation (Pinto; Andrade, 1999; Ruiz; Greco; Braile, 2009).

3.2 Critical Analysis of the Selected Studies

Table 3 presents interventions primarily focused on experimental experiences designed to promote children's interaction with nature and raise awareness about environmental issues. Among the nine studies, five are experimental, one is an action-research study with diverse samples (including children of different ages and contexts, such as camps and schools), and the remaining are literature reviews on the topic. Another relevant aspect is the choice in some studies to combine different participant groups to contrast different perspectives, as in the research that included both children and the elderly. Although it was not conducted in a school setting (Correira; Ramos, 2024), it addressed community awareness through environmental education, including practices such as educational sensory gardens, which can be adapted for pedagogical contexts.

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Table 3 – Main participants addressed by the studies and methodological nature of the research.

No.	Author(s)	Study Type	Participants
1	Caiola *et al.*	Experimental	62 children (36 boys and 26 girls), divided into two age groups: Group 1 (28 children aged 6–7) and Group 2 (33 children aged 8–9), attending a summer camp in Cornaredo, Lombardy, Italy.
2	Carrasco-Dionisio; Santos	Experimental	Students from the first cycle of Elementary School (aged 5 to 12) from public schools in the municipality of Votuporanga, Brazil.
3	Carvalho	Literature Review	Not specified.
4	Correira; Ramos	Experimental	Community members from the Obra Social Padre Miguel, including children and adults, focusing on environmental awareness and intergenerational preservation.
5	Fangwi; Tchombe	Experimental	15 participants (5 students, 5 teachers, 3 parents, and 2 caregivers of children with ASD), selected through purposive sampling.
6	Ghazali *et al.*	Experimental	Children aged 4 to 6 diagnosed with autism, participants of the Autism Center, a government reference center in Malaysia. Each classroom accommodates up to 8 students with 2 interventionists.
7	Queiroz *et al.*	Action Research	Teachers and 8th-grade students from lower secondary education, with the involvement of the school community in building the sensory garden and school vegetable garden.
8	Salsabila; Muna	Literature Review	Not specified.
9	Santos; Marafon	Literature Review	Not specified.

Source: Prepared by the authors (2024)

Sensory studies often include participants with various conditions, such as visual or motor impairments or developmental disorders. However, it was observed that none of the analyzed studies addressed deficits beyond cases of ADHD, Autism, or individuals without specific conditions.

In an effort to include other groups, one study analyzed the design of sensory gardens in public green spaces used by individuals with visual impairments and reduced mobility. The research explored the conception of sensory gardens as tools for knowledge acquisition, skill development, emotional regulation, and the promotion of self-confidence in individuals with special needs. It proposed the implementation of a sensory garden in an outdoor school area, aimed at children with visual impairments, based on the principles of universal design, to meet various sensory, emotional, and physical demands. The goal was to foster emotional and

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cognitive development while enhancing therapeutic benefits (Kopeva; Khrapko; Ivanova, 2020).

In the study by Sabbagh and Cuquel (2007), visits to the sensory garden for children with visual impairments were initially supervised by trained professionals who provided verbal guidance to facilitate perception and spatial orientation. After a few guided visits, it was considered that the children would develop autonomy to explore the space independently, strengthening their self-confidence and enabling their participation in playful and exploratory activities. This approach promoted interaction with the environment and enriched their sensory and social experiences (Sabbagh; Cuquel, 2007).

Table 4 presents the study results, highlighting that the integration of technologies, outdoor activities, and sensory design in educational settings supports the cognitive and sensory development of children. Moreover, it reinforces inclusive environmental awareness, benefiting both neurotypical students and those with special needs. These interdisciplinary approaches are essential for the holistic development of individuals, promoting socio-emotional skills and fostering inclusive and comprehensive education.

Table 4 – Results obtained from studies using different approaches to Sensory Gardens in the socio-educational context

No.	Author(s)	Study Results
1	Caiola *et al.*	The results indicated challenges such as usability limitations and a lack of continuity between indoor and outdoor experiences. The study suggested improvements to the tools and their expansion into primary schools, focusing on empowering children to program devices, promoting responsible design and sustainable attitudes.
2	Carrasco-Dionisio; Santos	The activities conducted in the sensory garden promoted a pleasant learning experience, allowing children to develop their perception of nature and gain a better understanding of biodiversity. Observations indicated that the activities fostered knowledge acquisition through interaction with the natural environment and cultural groups, supporting deeper and more contextualized learning.
3	Carvalho	The study emphasized the role of sensory gardens in the development of children and adolescents, especially in urban environments. By providing a contrast to excessive time spent indoors, these gardens promote health, well-being, and social inclusion, offering spaces for movement and interaction. Additionally, they help counter the effects of social isolation and foster student autonomy, functioning as an educational tool.

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4	Correira; Ramos	The implemented activities showed significant impacts on environmental awareness, leading to the replacement of plastic bottles with reusable ones and the creation of green murals. The research highlighted the importance of overcoming initial resistance and involving multiple generations to enhance environmental literacy. These practices led to concrete behavioral changes, such as waste reduction, and encouraged innovation in the school context.
5	Fangwi; Tchombe	The study demonstrated that therapeutic exposure to nature had a positive effect on children with ASD, promoting improvements in sensory integration, attention, motor skills, and cognitive functioning, as well as reducing anxiety. Natural environments such as gardens and aquatic areas proved essential in moderating sensory responses and supporting holistic development. Despite obstacles like parental insecurity, outdoor experiences were deemed fundamental for these children's development.
6	Ghazali *et al*.	The study highlighted the importance of sensory gardens as environments designed to meet the specific needs of children with autism. By minimizing distractions and stimulating the senses in a controlled manner, these gardens create a calm space that enhances learning and development. Creating such environments is essential for children to learn effectively and comfortably, thus promoting more inclusive education.
7	Queiroz *et al*.	The study showed that building the sensory garden led to new pedagogical experiences for students, characterized by dialogic learning and knowledge contextualization. The garden environment fostered greater integration and participation of the entire school community and significantly contributed to validating learning processes, reinforcing the inclusive and participatory nature of the school setting.
8	Salsabila; Muna	The research highlighted the benefits of nature-based learning for children with autism, noting significant improvements in cognitive, social, and emotional development. Natural and sensory environments offer an inclusive and non-threatening learning space, helping to reduce stress, increase engagement, and promote overall student well-being. These environments effectively support learning and social interaction.
9	Santos; Marafon	Sensory gardens proved to be a valuable pedagogical alternative, stimulating children's creativity, senses, and environmental awareness. When integrated into the school curriculum, these gardens promote a deeper learning experience, connecting children more meaningfully with nature and encouraging scientific and creative skills. Furthermore, they play a therapeutic role that contributes to students' overall well-being.

Source: Prepared by the authors (2024)

The studies analyze the convergence of pedagogical, socio-educational, and inclusive aspects, with a focus on children and adolescents - especially those with disabilities - and their interaction with the natural environment. Caiola *et al*. (2023) propose the integration of technology and nature, suggesting that physical-digital technologies can enrich outdoor educational experiences without replacing contact

with the natural environment, offering an inclusive approach that benefits children with diverse abilities.

The study by Caiola *et al*. (2023) can be further complemented by highlighting that the use of the senses facilitates the graphic representation of information acquired through vision, hearing, touch, smell, and temperature perception. The recording of these perceptions - such as notes, drawings, photographs, and videos - connects concrete sensations with graphic and numerical sensor data. For example, audio recordings associate auditory sensations with graphs that indicate sound intensity levels (Silva, 2023).

In the field of Environmental and Inclusive Education, Correira; Ramos (2024) emphasize the importance of environmental education in both formal and informal contexts, exemplified by their activities at a social institution in Portugal. The adoption of simple practices to reduce the ecological footprint fosters environmental awareness and creates an inclusive environment, allowing all participants - regardless of their condition - to engage in awareness-raising activities, with a focus on practical actions and the development of sensory skills.

Within the context of neurodiversity, some studies go beyond traditional educational settings and focus on therapeutic interventions, such as Nature-exposure therapy for children with Autism Spectrum Disorder (ASD). Fangwi; Tchombe (2024) explore how Nature-exposure therapy can benefit children with ASD by promoting improvements in sensory, cognitive, and social domains. This approach offers an inclusive pedagogical perspective by integrating therapeutic activities into natural environments to enhance the well-being and learning of autistic children - an advancement in pedagogical practices for special needs education.

Also from the perspective of special needs, Nature-Based Learning (NBL) has emerged as a promising approach for children with Autism Spectrum Disorder (ASD). The positive impacts of this methodology are highlighted, showing that calm and collaborative environments promote communication and social development. NBL suggests that outdoor activities in non-threatening contexts are essential for the psychosocial development of these children (Salsabila; Muna, 2023).

Additionally, emphasizing the importance of inclusion and social interaction, the study by Carvalho (2022) explores how outdoor activities - such as sensory

gardening - can benefit young people with Attention Deficit Hyperactivity Disorder (ADHD). These practices create learning environments that stimulate sensory perception and foster connection with nature, contributing to the development of social and interpersonal skills. Such advances are fundamental for integrating these students into society and strengthening inclusive and accessible pedagogical practices.

There is also a concern among authors such as Ghazali, Md Sakip and Samsuddin (2019) regarding how environmental settings can support the learning process of students with autism. According to these studies, the creation of sensory-appropriate and calming spaces can facilitate knowledge acquisition, reduce stress, and promote a more inclusive and conducive environment for the academic and social development of these students. These approaches reinforce the relevance of pedagogical practices tailored to the specific needs of neurodivergent individuals.

Other studies (Carrasco-Dionisio; Santos, 2016; Santos; Marafon, 2024) highlight the potential of sensory gardens as pedagogical tools, providing children — including those with disabilities — with the opportunity to explore their senses in a natural setting. These spaces are established as non-formal learning environments that support the development of cognitive and emotional skills, while also promoting environmental awareness in an inclusive and accessible manner.

In a study by Hussein (2012) on the use of zones within sensory gardens, it was observed that students with special educational needs tend to engage more in individual activities than in group ones, regardless of the zone size. The number of activities and time spent on them were not related to zone size but rather to access behavior-setting configurations.

Schools that implement pedagogical practices based on environmental education have the opportunity to raise students' awareness about the environment by promoting direct contact with natural elements. The sensory garden emerges as a valuable pedagogical tool, combining theoretical learning with practical experience, stimulating the senses, and reinforcing environmental awareness (Almeida *et al.*, 2017).

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Such pedagogical practices also stimulate students' creativity, problem-solving, and critical thinking, preparing them to face the challenges of the 21st century. Innovative pedagogical strategies grounded in an interdisciplinary approach have the potential to enhance students' learning processes by providing more meaningful and comprehensive educational experiences. The implementation of these strategies can lead to a more engaging and effective learning environment, promoting both academic growth and personal development (Fernandes *et al*., 2024).

Table 5 summarizes the analysis of the applications and approaches of the studies on sensory gardens, dividing them into two groups: one with practical and direct applications, and the other with more general approaches that contribute indirectly to the topic.

Table 5 – Characterization of the studies according to focus and type of approach to the theme

No.	Author(s)	Focus	Type of Approach
1	Caiola *et al*.	Integration of digital technologies	Generalist
2	Carrasco-Dionisio; Santos	Sensory experience and biodiversity	Applied
3	Carvalho	Well-being and social inclusion in ADHD	Generalist
4	Correira; Ramos	Environmental awareness	Generalist
5	Fangwi; Tchombe	Therapeutic effects on ASD	Applied
6	Ghazali *et al*.	Sensory gardens designed for ASD	Applied
7	Queiroz *et al*.	Construction and community impact	Applied
8	Salsabila; Muna	Nature-based learning	Applied
9	Santos; Marafon	Curricular and therapeutic integration	Applied

Source: Prepared by the authors (2024)

It is evident that, regardless of the approach, sensory gardens have a significant impact as a pedagogical strategy for promoting inclusive environmental education, especially in the learning and integration of students with and without special needs. These impacts can be synthesized into the following key areas: integration and inclusion (Queiroz *et al*., 2022; Santos; Marafon, 2024), sensory stimulation and cognitive development (Fangwi; Tchombe, 2024; Ghazali; Md Sakip; Samsuddin, 2019; Salsabila; Muna, 2023), connection with nature and environmental awareness (Carrasco-Dionisio; Santos, 2016; Correira; Ramos, 2024), personalized and inclusive learning (Carvalho, 2022; Santos; Marafon, 2024), social and

community impact (Queiroz *et al*., 2022; Santos; Marafon, 2024), and emotional well-being and stress reduction (Ghazali; Md Sakip; Samsuddin, 2019; Salsabila; Muna, 2023). Thus, all these aspects can be intentionally incorporated into pedagogical practice.

3.2.1 Identification of Sensory Elements Present in Sensory Gardens for Environmental Education Learning

Sensory gardens, composed of elements such as textures, scents, colors, sounds, and interactive natural spaces, serve as inclusive pedagogical tools for environmental education. Their implementation, especially in schools, supports cognitive, social, and emotional development while promoting environmental awareness. The integration of physical-digital systems (Caiola *et al*., 2023), the use of flowers and thematic murals (Correira; Ramos, 2024), and natural environments such as gardens and aquatic spaces (Fangwi; Tchombe, 2024) stimulate sensory perception and well-being, particularly in children with autism. Collaborative initiatives among educators, parents, and healthcare professionals (Santos; Marafon, 2024) enhance the positive impact of these spaces by promoting representative learning and understanding of natural processes.

Sensory learning, as emphasized by Piaget and Petit (1986) and Montessori (1987), plays a key role in the development of formal operations, particularly in the transition from concrete to abstract thinking. Practical activities in which students engage their senses to gather information from their surroundings facilitate cognitive progression and promote the development of increasingly complex and abstract levels of thought. This process is essential for acquiring 21st-century skills such as problem-solving and critical thinking (Turiman *et al*., 2012).

In this context, landscapes — especially those composed of therapeutic plants — have the potential to strongly stimulate all five senses. The design of these landscapes may include elements such as the shapes, textures, movements, light, and shadows of plants to stimulate vision. Aromatic plants activate the sense of smell, while the sound of wind rustling through the leaves and stems stimulates

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hearing. The presence of fruits, vegetables, herbs, and spices provides gustatory stimulation. Additionally, some plants are selected for their durability and texture variety, offering tactile experiences (He *et al*., 2022).

The learning environment and the resources available are essential for promoting learning in schools, acting as determining factors in student performance. A well-structured environment motivates students to actively engage in the educational process, influencing their behavior and contributing to the development of skills and perceptions. Suitable school environments directly impact children's physical, cognitive, social, and emotional development, highlighting the importance of educational space in the learning process (Shaari; Ahmad, 2016). According to Bissoto (2005), for inclusive education to succeed, schools must reassess their goals and social function, rethinking the meaning of teaching and learning processes.

3.2.2 Benefits and Socio-Educational Effectiveness of Sensory Gardens in Promoting Inclusive Practices

The analysis of data concerning the studies and the application of sensory gardens in various contexts (Table 4) led to the creation of a word cloud (Figure 3), which highlights key aspects within the socio-educational domain. Terms such as "inclusive," "development," "children," "interaction," and "sensory" appeared most frequently, underscoring the focus on inclusion and holistic development. Additionally, words like "environments," "learning," "integration," and "emotional" indicate the recognition of sensory gardens as effective tools for promoting experiential learning, fostering environmental awareness, and supporting socio-emotional development.

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Figure 3 – Word cloud representing the main terms related to the use of sensory gardens as inclusive educational tools, generated based on the data from Table 4.

Source: Prepared by the authors (2024)

These results support the idea that sensory gardens offer a multidimensional approach, addressing both pedagogical needs and collective well-being (Toledo; Cordeiro, 2023). The frequency of key terms highlights sensory gardens as inclusive spaces that encourage engagement and interaction, reinforcing their role in transformative educational practices. They function as collaborative pedagogical environments, fostering school community participation and promoting more meaningful learning. In summary, they contribute to students' educational and social development by promoting inclusion, personalized learning, and emotional well-being with lasting impacts (Queiroz *et al.*, 2022; Salsabila; Muna, 2023).

Understanding the student and their individual characteristics, maintaining ongoing dialogue with families, and seeking adaptations that align the educational process with students' strengths are viable strategies across various educational contexts. However, the effectiveness of such inclusive practices requires careful environmental planning and, above all, intentional pedagogical intervention. Through this planned approach, inclusive practices can be developed, becoming innovative and respected, and ensuring that all students have equitable learning opportunities

(Santos; Teles, 2012).

The studies analyzed highlight the effectiveness of sensory gardens in inclusive school settings, demonstrating their role as facilitators of integration among students with different abilities. These spaces meet students' individual needs, promoting personalized education. Sensory gardens support inclusive educational practices that benefit both students with special needs and neurotypical peers, while encouraging cooperation and collaborative learning. Moreover, these environments have the potential to engage the wider community, expanding inclusion practices and creating a more welcoming and accessible space, strengthening community ties and enhancing school relationships.

From the perspective of inclusive education, sensory gardens are widely recognized as essential tools for promoting both inclusion and learning. These spaces have the potential to stimulate underutilized senses and serve as accessible environments not only for individuals with special needs or undergoing rehabilitation but also for the general public. Functioning as educational and socially inclusive environments, sensory gardens foster the participation and engagement of individuals with diverse needs. In addition, they offer the opportunity to practically replicate various features of natural ecosystems, enriching the sensory experience and deepening the connection with the environment (Ely *et al*., 2006).

For a student to expand their social relationships and fully integrate into society, it is essential that they feel a sense of belonging and inclusion within the school environment. This feeling of belonging is crucial to understanding social dynamics and developing a new perspective on one's role as an individual within human society. Thus, the sense of belonging to school directly impacts academic performance and is a determining factor in the student's development as a socio-historical subject. In other words, it contributes to the construction of identity and the understanding of social dynamics, facilitating social integration and the development of socio-emotional skills (Nobre, 2019).

As a pedagogical tool, the sensory garden proves to be feasible for the learning process by stimulating environmental awareness through the senses and direct interaction with space. This inclusive approach benefits both individuals with and without disabilities, providing experiences that go beyond traditional learning

(Marins; Moraes; Portugal, 2023). However, a gap remains in the academic literature regarding the understanding of sensory gardens and the impact of this knowledge on teacher training. This gap highlights the need to investigate how these spaces can be incorporated into pedagogical planning, expanding educators' competencies in inclusive and innovative teaching practices (Marins; Moraes; Portugal, 2023).

Pedagogical practices in sensory gardens have stood out as effective tools for promoting social interaction, especially for individuals with Autism Spectrum Disorder (ASD). Characterized by difficulties in communication and social interaction, ASD often involves language impairments and a unique perception of the world, based on specific interests and skills. The sensory garden environment, with its variety of natural stimuli, allows these abilities to serve as starting points for social integration, creating a bridge between the autistic individual and the social environment through a connection with nature (Santos; Marafon, 2024).

Although beneficial, sensory gardens are still rarely implemented in Brazil due to a lack of dissemination and recognition as tools for inclusive education and social interaction (Tavares; Moraes; Portugal, 2023). This limited visibility restricts institutional and community awareness of their pedagogical and therapeutic potential, resulting in lower impact in studies illustrating this scenario.

Conclusion

Based on the study of the impacts of sensory gardens as an educational strategy, it was demonstrated that, among the pedagogical impacts, the promotion of experiential learning, the development of cognitive and motor skills, as well as the stimulation of curiosity and environmental awareness stand out. Interactions within sensory gardens foster a more contextualized understanding of content, making teaching more inclusive. The use of sensory elements, such as plants, sounds, and textures promotes the development of the senses through a holistic and differentiated teaching approach that meets the needs of all students while respecting their individual characteristics.

From a social perspective, studies indicate that sensory gardens strengthen student relationships, promote respect for diversity, and contribute to emotional

well-being. For students with disabilities, these spaces serve as safe and welcoming environments that encourage social interaction and autonomy. For others, they offer opportunities to develop empathy, environmental awareness, and collective responsibility.

Thus, sensory gardens have demonstrated high applicability in the context of inclusive environmental education due to their pedagogical potential and their ability to promote equity in access to knowledge. Their implementation in schools may represent a significant step forward in building more accessible, sustainable, and humanized educational environments.

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