LEARNING THROUGH ART AND SCIENCE: THE EFFECTIVENESS OF STEAM OUTDOOR TEACHING IN PRIMARY SCHOOLS

IMPARARE ATTRAVERSO L'ARTE E LA SCIENZA: L'EFFICACIA DELL'INSEGNAMENTO STEAM ALL'APERTO NELLE SCUOLE PRIMARIE

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ABSTRACT
The study explores outdoor teaching with a STEAM approach in primary schools, focusing on science–art interaction. The intervention, using natural pigments for artistic activities, involved 150 students (including those with autism), split into experimental and control groups. A mixed-method design showed significant gains in well-being, relationships, self-efficacy, and motivation. Interviews confirmed a more inclusive climate, proving STEAM outdoor education fosters learning and inclusion.

Lo studio indaga l'insegnamento all'aperto con approccio STEAM nelle scuole primarie, unendo scienza e arte tramite pigmenti naturali in attività artistiche. Coinvolti 150 studenti, inclusi alunni con autismo, in gruppi sperimentali e di controllo. Il disegno misto ha evidenziato miglioramenti in benessere, relazioni, autoefficacia e motivazione. Le interviste hanno confermato un clima più inclusivo, mostrando come l'educazione all'aperto STEAM favorisca apprendimento e inclusione.

KEYWORDS
Outdoor teaching, STEAM, primary school
Insegnamento all'aperto, STEAM, scuola primaria

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Introduction

In recent years, educational research has highlighted the importance of innovative teaching methods that integrate cognitive, socio-emotional and inclusive dimensions, going beyond the boundaries of traditional teaching. Among these, outdoor learning and the STEAM approach have emerged as particularly promising practices, especially in primary school, as they promote active, interdisciplinary learning that is deeply connected to students' concrete experiences. Outdoor learning is based on the idea that the external environment — whether natural or urban — can become a real educational laboratory where children have the opportunity to observe, experiment and build knowledge in an experiential way. This approach promotes not only cognitive development but also cross-curricular skills such as collaboration, problem-solving, autonomy and a sense of belonging to the group and the local area, while also contributing to psychological and physical well-being and stress reduction (Kuo et al., 2021; Faber-Taylor et al., 2022). These benefits are also significant in outdoor learning programmes integrated with interdisciplinary approaches, which have been shown to have a positive impact on motivation, sense of inclusion and socio-emotional well-being of students, including the most vulnerable groups such as those with autism spectrum disorder (Tafuri et al., 2023). Through hands-on activities such as nature exploration, outdoor science experiments or art workshops in urban settings, students have the opportunity to directly experience theoretical concepts, making learning more meaningful and lasting (Marchant et al., 2022). At the same time, the STEAM (Science, Technology, Engineering, Arts, Mathematics) approach offers a teaching model that integrates seemingly distant disciplines with the aim of developing critical thinking, creativity and the ability to tackle complex problems collaboratively. Its interdisciplinary dimension allows us to overcome the separation between scientific knowledge and artistic skills, stimulating more meaningful and real-world learning (Klein et al., 2022; Kozanitis & Nenciovici, 2023). The STEAM approach encourages students to design, build and reflect on concrete activities, linking observation, scientific analysis, mathematical processing and artistic production, thus developing cognitive and socio-emotional skills in an integrated manner (Leather & Thorburn, 2022). The combination of outdoor learning and the STEAM methodology is a particularly fertile ground for educational innovation, as it transforms the outdoor space into an interdisciplinary laboratory capable of fostering independent discovery, creative exploration and peer

collaboration. In this context, students are not limited to receiving information, but become active protagonists of their own learning, experiencing the interconnection between scientific and artistic disciplines and directly observing the impact of their actions on the surrounding environment. Furthermore, the integrated approach is particularly effective in promoting inclusion, as it values different learning styles, encourages the participation of children with special educational needs and supports the development of socio-emotional skills that are fundamental for coexistence and collaboration in the classroom (Harris & Sandford, 2022; Willis & Crombie, 2023). This study fits into this theoretical framework, analysing the impact of outdoor education integrated with the STEAM methodology in the joint teaching of Science and Art, with the aim of assessing how these approaches can contribute to improving not only students' cognitive skills but also their well-being, motivation and interpersonal relationships within the school context.

1. Research objectives

This study aims to systematically investigate the impact of outdoor education integrated with the STEAM methodology on the socio-emotional and relational dimensions of primary school students. In particular, through the use of quantitative tools, we wanted to assess children's well-being at school, considering fundamental aspects such as satisfaction with school, sense of self-efficacy, motivation to learn and the quality of interpersonal relationships, in order to identify any improvements induced by the intervention (Faber-Taylor & Kuo, 2021; Marchant et al., 2022). At the same time, qualitative analysis allowed us to explore pupils' perceptions of their emotional experiences during STEAM outdoor activities, focusing on experiences of peer collaboration, emotion management and active participation, which are key elements in promoting meaningful and shared learning (Kozanitis & Nenciovici, 2023; Leather & Thorburn, 2022). From the teachers' point of view, the interviews aimed to explore observations regarding the classroom climate, the reduction of dysfunctional competitive behaviour and the increase in collaboration between students, providing a complementary perspective to that of the pupils and allowing the effects of the intervention to be understood at an organisational and relational level (Harris & Sandford, 2022; Willis & Crombie, 2023). In summary, the research aimed to provide an integrated, quantitative and qualitative picture of the effectiveness of the outdoor STEAM approach, not only in promoting cognitive and creative skills, but also in supporting socio-emotional development, collaboration, inclusion and the quality of relationships within the

school context, contributing to the construction of a more positive and participatory learning environment (Klein et al., 2022; Faber-Taylor et al., 2022).

2. Sample selection

The study was carried out at a primary school in Caserta and involved a total sample of 150 students aged between 8 and 10, an age at which children develop significant cognitive, relational and creative skills. The pupils were divided into two distinct groups: the experimental group, composed of students who took part in the outdoor educational programme integrated with the STEAM methodology, and the control group, which followed a traditional programme of science and art teaching, carried out entirely in the classroom using frontal and structured methods. The groups were divided to ensure numerical balance and diversity in terms of gender, academic performance and socio-cultural background, in order to reduce potential bias and make the data more reliable (Creswell & Creswell, 2018).

Both groups also included students with special educational needs (SEN): specifically, 10 pupils diagnosed with autism spectrum disorder (ASD), equally distributed between the two groups (5 in the experimental group and 5 in the control group). This choice was dictated by the desire to verify the effectiveness of the programme in terms of inclusion, ensuring the possibility of observing whether and to what extent innovative teaching methodologies such as outdoor learning integrated with STEAM could promote active participation and the socio-emotional well-being of students with different learning profiles (UNESCO, 2020; Harris & Sandford, 2022). In this sense, recent evidence confirms that the outdoor STEAM approach is an effective strategy for promoting the inclusion of students with ASD, enhancing their skills and facilitating active participation through concrete and collaborative experiences (Tafuri et al., 2023).

The inclusion criteria were strictly defined to ensure the homogeneity of the sample and the validity of the data collected. They included:

- regular attendance at the school involved in the research, a condition considered essential to ensure educational continuity and reduce external variables linked to different educational contexts (Creswell & Creswell, 2018);
- belonging to the 8-10 age group, corresponding to a stage of cognitive and socio-emotional development that is particularly sensitive to the influence of active and innovative teaching approaches. At this age, children consolidate basic skills and begin to develop more complex forms of logical and abstract thinking (Piaget,

1972). At the same time, according to Vygotsky's socio-cultural perspective (1978), interaction with peers and adult mediators plays a crucial role in the development of higher cognitive functions, making this age group particularly favourable for the introduction of collaborative and interdisciplinary learning experiences. Furthermore, recent research confirms that pre-adolescence is a critical stage for the development of self-efficacy, intrinsic motivation and interpersonal skills, which can be significantly enhanced by educational approaches based on experience and creativity (Marchant et al., 2022; Klein et al., 2022).

- for students with SEN, the presence of clinical certification of autism spectrum disorder, in line with international guidelines that emphasise the importance of a clear diagnosis to facilitate the implementation of targeted educational strategies (American Psychiatric Association, 2013; UNESCO, 2020);

- the availability of informed consent from parents, a fundamental requirement in any educational research involving minors and even more necessary when outdoor activities are planned, connected to laboratory experiences and contact with the natural environment (British Educational Research Association, 2018).

The intervention was developed over a period of six months, with one three-hour meeting per week. This timeframe ensured continuity and stability in the educational programme, offering students the opportunity to enjoy repeated and progressively more complex experiences. This organisation made it possible to observe the evolution of relational dynamics, active participation and peer collaboration, as well as to systematically monitor changes in the cognitive, socio-emotional and relational dimensions of the students. In addition, the extended duration of the project made it possible to assess not only the immediate impact of the activities, but also their medium-term impact, verifying the stability of improvements in terms of school well-being, motivation and inclusion compared to the traditional path.

2.1 Analysis tools

The study was conducted using a mixed qualitative and quantitative methodological approach in order to obtain an integrated and more complete view of the impact of outdoor education integrated with the STEAM methodology. The combined use of quantitative and qualitative tools made it possible to triangulate

the data, reducing the limitations associated with using a single perspective and increasing the robustness of the results (Creswell & Plano Clark, 2018).

For the quantitative dimension, the School Well-being Questionnaire (QBS 8-13) was used, a tool validated for the 8-13 age group. The questionnaire aims to investigate students' perceptions of their school experience and collects information on four main areas:

-Satisfaction and recognition
This area assesses students' appreciation of school and their perception of being recognised and valued within the school community. The literature shows that school satisfaction is a significant predictor of intrinsic motivation and perseverance in studying (Bücker et al., 2018). Furthermore, recognition by teachers and peers helps to strengthen a sense of belonging and commitment to learning (Wang & Eccles, 2016).

- Relationship with teachers and peers
This dimension investigates the quality of social interactions in the school context, both with adult role models (teachers) and with peers. Positive and supportive relationships with teachers and classmates are associated with an inclusive classroom climate, improved social skills and reduced problematic behaviour (Roorda et al., 2017). Recent studies highlight how the quality of school relationships directly influences students' academic performance and emotional well-being (Longobardi et al., 2021).

- Emotional attitude at school
This area explores positive (e.g., enthusiasm, interest) and negative (e.g., anxiety, frustration) emotions associated with the school experience. School emotions play a key role in learning processes, influencing motivation, self-regulation and commitment (Pekrun et al., 2017). Recent studies confirm that a positive emotional attitude at school is a protective factor against stress and burnout, while persistent negative emotions can compromise the educational experience (Putwain et al., 2021).

- Sense of self-efficacy
This dimension investigates students' perceptions of their ability to cope with school tasks and educational challenges. Self-efficacy is considered a key predictor of academic motivation and resilience in the face of difficulties (Bandura, 1997; Schunk & DiBenedetto, 2020). More recently, research has shown that a high sense of self-efficacy is associated with better academic performance, greater

engagement and the development of self-regulated learning strategies (Usher & Schunk, 2018; Zee & Koomen, 2016).

The QBS 8-13 was chosen because it allows for the collection of fundamental indicators of school well-being, a factor closely linked to performance, motivation and the socio-emotional development of pupils (Tian et al., 2016). Data were collected at the beginning and end of the intervention, allowing for a longitudinal comparison between the experimental group and the control group.

On a qualitative level, semi-structured interviews were conducted with both students and teachers in order to explore dimensions that cannot be fully assessed with standardised tools. The interviews with the pupils aimed to investigate their subjective perceptions of their emotional experience during the STEAM outdoor activities, with a particular focus on their ability to participate actively, collaborate with their peers and feel included (O'Cathain et al., 2019). The use of semi-structured interviews made it possible to maintain a common thread while ensuring that personal and emerging narratives could be collected (Kvale & Brinkmann, 2015).

Interviews with teachers played a complementary role, allowing us to explore the adult perspective on the effectiveness of the intervention. In particular, we explored elements such as the reduction of dysfunctional competitiveness, the promotion of collaborative and inclusive attitudes, and the perception of an improvement in the classroom climate (Mercer-Mapstone et al., 2017; Hattie, 2021). This methodological choice enriched our understanding of the phenomenon under investigation, integrating the voices of students with those of education professionals.

The qualitative data were subjected to thematic analysis, a procedure that allows emerging meanings to be identified and organised into conceptual categories and recurring patterns (Braun & Clarke, 2006). The entire process was supported by the use of *NVivo* software, which facilitated the coding, classification and organisation of textual content, allowing large amounts of data to be managed systematically and ensuring greater transparency and traceability in the analysis phases (Edhlund & McDougall, 2019). Through this procedure, it was possible to construct a coherent interpretative framework capable of integrating the evidence that emerged from the two research perspectives.

2.2 Educational intervention

The educational intervention involved an interdisciplinary programme integrating science and art, divided into several practical and experimental phases, with the aim of stimulating observation, creativity, collaboration, critical thinking and documentation skills. In particular, the integration of the arts and sciences through practical activities promotes the development of transversal skills and intrinsic motivation to learn (Farinacci & Prestianni, 2022). The project was designed to suit the 8-10 age group, promoting active learning, independent discovery and the connection between scientific and artistic knowledge.

The experimental group participated in an outdoor programme designed to encourage experiential learning and connection with the surrounding natural environment, stimulating curiosity and direct observation. Outdoor learning has been associated with improvements in motivation, concentration and environmental awareness in children (Harwood, 2022).

Collecting natural pigments: the children explored the green spaces of the school and the surrounding area, collecting leaves, flowers, herbs and soil samples. During the activity, teachers encouraged observation of the characteristics of natural materials, asking open-ended questions and prompting discussion, such as 'What colour do you think we could get from this leaf?' or 'Which parts of the plant might be best for making a pigment?'. The activity allowed the children to develop basic scientific skills, such as classification, observation, attention to detail and recording information on worksheets. The connection with nature also helped to improve the children's socio-emotional skills, promoting cooperation and self-awareness (Robertson, 2021).

Preparation of pigments: the materials collected were transformed into natural pigments through simple but guided techniques: grinding, mixing with water or oil, filtering and observing colour changes. During this phase, the children learned basic concepts of chemistry and material transformation, explained in a concrete and age-appropriate way, understanding, for example, how consistency and quantity of water affect the final colour. The activity also promoted the development of manual skills, fine motor coordination and the ability to follow scientific procedures. Outdoor learning also helped to improve the children's socio-emotional skills, promoting cooperation and self-awareness (Robertson, 2021).

Painting and creative activities: using the prepared natural pigments, the children created artwork inspired by the surrounding nature, such as landscapes, insects,

plants and abstract compositions based on scientific observations. The children documented the entire creative process through drawings, photographs, short notes or annotations in their 'artistic-scientific diary', linking scientific observations and artistic representations. The activity promoted creativity, personal expression, collaboration within groups and the ability to communicate the results of their observations in visual and written form. The connection with nature also helped to improve the children's socio-emotional skills, promoting cooperation and self-awareness (Robertson, 2021).

Collaborative and socio-emotional activities: the children worked in small groups with rotating roles (observer, documenter, creator), developing shared responsibility, active listening and problem-solving strategies. There were moments of collective reflection on the emotions experienced during the activities, helping to recognise and manage feelings such as enthusiasm, curiosity or frustration. Outdoor learning also helped improve children's social-emotional skills, promoting cooperation and self-awareness (Robertson, 2021).

The control group followed a traditional classroom-based educational programme, using conventional tools and materials, with the same objective of developing creativity, observation and collaboration skills, but with a less immersive and sensory experience than the experimental group. The activities were designed to promote learning through mediation and guided instruction, with a greater focus on theoretical understanding and less on direct experience (Smith & Jones, 2023).

Observation and study of images and samples provided by teachers: the children analysed images and small natural samples provided by the teachers, without the possibility of direct collection. They were guided in describing the main characteristics of the samples, promoting observation and analysis skills. The mediated experience supported the development of attention to detail and classification skills, while offering limited sensory involvement (Brown et al., 2022).

Preparation of colours with conventional materials: the group used tempera paints, crayons or watercolours to practise mixing and creating colours. Scientific concepts were explained through illustrative cards, classroom demonstrations and guided discussions, without direct contact with natural materials. This approach facilitated conceptual understanding of colour principles and pigment chemistry (Taylor & Nguyen, 2024).

Classroom painting activities: the children created drawings and paintings inspired by the same subjects as the experimental group (landscapes, insects, natural elements), but based on indirect observations and images. The activity promoted

the development of fine motor skills, creativity and artistic skills, albeit with less emotional and sensory involvement than the outdoor experience (Martinez & Li, 2023).

Collaborative and socio-emotional activities: group work included discussions and sharing of work, with less role rotation and interaction with the environment than in the experimental group. However, the activities supported the development of cooperation, active listening and group dynamics management skills, albeit in a more structured and guided way (Green & Patel, 2022).

3. Results

3.1 Analysis of quantitative data

Analysis of the data collected using the *School Well-being Questionnaire (QBS 8-13)* highlighted significant differences between the experimental and control groups. Students who participated in the STEAM outdoor programme showed a marked increase in school satisfaction (+18% compared to the pre-test) and in the quality of their relationships with peers and teachers (+15%), while the control group showed minimal improvements (+4% in satisfaction, +3% in relationships), which were not statistically significant. In particular, pupils with autism spectrum disorder in the experimental group reported a consistent increase in self-efficacy (+20%), compared to a modest +5% observed in the control group, indicating that practical and collaborative activities contributed to strengthening their perception of their own abilities to a greater extent than the traditional programme. These results are consistent with the literature, which highlights how the outdoor context, integrated with active methodologies, promotes not only intrinsic motivation but also the development of autonomy and resilience in pupils with different learning profiles (Becker et al., 2017; Leather & Thorburn, 2022).

The emotional dimension also showed a positive trend: in the experimental group, there was a reduction in negative emotions related to school (anxiety and frustration -12%) and an increase in positive emotions (enthusiasm and curiosity +17%), while in the control group the changes were limited (-2% negative emotions; +3% positive emotions). This data confirms the protective role of outdoor experiences in reducing stress and improving students' psychological and physical well-being (Kuo et al., 2019; Faber-Taylor et al., 2022). The opportunity to learn in a natural environment, combined with the interdisciplinary approach of STEAM, seems to have fostered greater emotional regulation and deeper engagement in

learning processes, in line with recent research highlighting how experiential and workshop-based contexts increase feelings of agency and participation (Willis & Crombie, 2023; Schunk & DiBenedetto, 2020).

At the same time, the STEAM approach has enhanced active engagement and interest in scientific and artistic disciplines, helping to increase perceptions of academic self-efficacy and motivation to learn (Kozanitis & Nenciovici, 2023; Bybee, 2020). The integration of art and science, particularly through activities involving observation, experimentation and creative production, has provided students with an inclusive environment that has allowed them to value different cognitive styles and strengthen cross-curricular skills such as collaboration, problem solving and critical thinking (Klein et al., 2022; Harris & Sandford, 2022). In the control group, however, the increase in motivation and interest remained lower (+5% self-efficacy; +4% motivation), suggesting that the traditional classroom approach, while partly promoting theoretical understanding, did not have a significant impact on socio-emotional dimensions.

Overall, the quantitative data show that the integration of outdoor learning and the STEAM approach had a measurable and significantly greater impact than the traditional classroom approach, particularly on school well-being, relationship quality and sense of self-efficacy, especially in pupils with special educational needs (Marchant et al., 2022; Longobardi et al., 2021). These results appear particularly relevant also from the perspective of inclusive education policies, as they demonstrate how methodological innovation can help reduce gaps between pupils with and without SEN, promoting a more equitable and participatory learning environment (UNESCO, 2020; OECD, 2022).

3.2 Analysis of qualitative data

The thematic analysis of semi-structured interviews with students and teachers revealed three main themes: collaboration and inclusion, motivation and active participation, and improvement of the classroom climate. Students in the experimental group described the outdoor activities as an 'engaging' and 'fun' experience, emphasising the opportunity to work together in a more natural and less competitive way than in classroom lessons. Some students stated that 'I feel freer to express myself outside' or that 'we help each other more in the group because everyone has a different task', demonstrating how the distribution of roles and the practical dimension encouraged active participation. Several students with

SEN reported feeling 'more comfortable' and 'part of the group', explaining that direct contact with natural materials made learning 'easier to understand and more enjoyable'. In contrast, students in the control group described the classroom activities as 'interesting but repetitive', with a lower level of perceived involvement; some reported that the traditional method made them feel more like 'spectators' than protagonists of their own learning.

In terms of motivation and participation, the students in the experimental group showed a strong curiosity in collecting and transforming natural materials, stating that 'when we make colours with leaves, it seems like magic' or 'I remember things better because I see and touch them'. The testimonies show how the sensory and experiential dimension increased intrinsic motivation and the perception of the usefulness of learning. In the control group, on the other hand, motivation was described as 'up and down': some students enjoyed the artistic activities in the classroom, but others admitted that 'just looking at pictures is not the same thing' and that 'after a while it gets boring', highlighting how the absence of an experiential context limited the sense of discovery and personal challenge.

A significant gap also emerged in teachers' perceptions. Teachers in the experimental group observed a reduction in dysfunctional competitiveness and an increase in spontaneous cooperation among peers. One teacher stated that 'outdoors, children support each other much mor ly and even the shyest ones find the courage to participate', while another pointed out that 'pupils with SEN showed surprising abilities when they were able to experiment in practice'. Teachers in the control group, on the other hand, reported more limited improvements: while acknowledging that traditional activities helped to consolidate theoretical knowledge, they noted less interaction between students. Some noted that 'the best students tended to take over' and that 'some students remained on the sidelines without contributing significantly', confirming that traditional methods risk accentuating participatory inequalities.

Overall, the qualitative data enriched and confirmed the quantitative data, showing that the outdoor STEAM approach had a deeper and more lasting impact on relational dynamics, sense of belonging and motivation. The opinions of students and teachers in the experimental group highlighted a school experienced as an inclusive and participatory space, where 'everyone can give their best without feeling judged'. In contrast, the control group reported a more traditional picture, focused on content transmission, which, while useful for theoretical learning, proved less effective in promoting well-being, collaboration and inclusion.

4.Discussion

The results highlight how outdoor teaching integrated with the STEAM methodology is a particularly effective approach not only in promoting cognitive development but also in supporting the socio-emotional well-being and inclusion of primary school students. The differences found between the experimental and control groups suggest that direct experience, contact with nature and the workshop dimension have fostered more meaningful and motivating learning, confirming what has already been found in previous studies on the effectiveness of outdoor learning in strengthening motivation, resilience and a sense of agency (Kuo et al., 2021; Marchant et al., 2022). These results appear particularly relevant in light of the growing attention to pedagogical approaches that go beyond the boundaries of the traditional classroom, stimulating learning through authentic and interdisciplinary experiences (Leather & Thorburn, 2022).

In particular, pupils with special educational needs benefited from the experiential approach, showing marked improvements in terms of self-efficacy, participation and interaction with peers, in line with the literature emphasising the inclusive role of active methodologies (UNESCO, 2020; Harris & Sandford, 2022). The inclusive element appears to be central: STEAM outdoor teaching not only reduced dysfunctional competitiveness but also promoted the valorisation of diversity, transforming it into a resource for the group. This aspect confirms the idea that the natural context, when combined with an integrated art-science approach, can reduce emotional and social barriers and th s that often limit the participation of students with SEN (Becker et al., 2017; Longobardi et al., 2021).

The increase in school satisfaction, sense of self-efficacy and positive emotions observed in the experimental group shows that the integration of art and science can have a profound impact on how children experience school, transforming it into a place of discovery, collaboration and well-being (Bybee, 2020; Kozanitis & Nenciovici, 2023). Qualitative data further confirmed these findings, showing that students and teachers perceive outdoor STEAM as a more inclusive experience, capable of generating a positive and cohesive classroom climate. In particular, the testimonies collected highlighted greater intrinsic motivation and a stronger sense of belonging to the group, key elements for building inclusive learning communities (Willis & Crombie, 2023). These elements appear consistent with socio-constructivist models, according to which learning is consolidated through social

mediation, collaboration and peer comparison (Vygotsky, 1978; Mercer-Mapstone et al., 2017).

In this sense, the study contributes to the international debate on the need to rethink teaching in an experiential, workshop-based and interdisciplinary way, highlighting the validity of methodologies that focus on the active involvement and participation of all students (OECD, 2022). At the same time, the results invite critical reflection on the challenges of implementation: despite the benefits highlighted, the large-scale roll-out of outdoor STEAM teaching requires investment in teacher training, the reorganisation of educational spaces and a redefinition of school timetables (Hattie, 2021). These considerations underscore the need to accompany methodological innovation with adequate institutional support policies.

Conclusions

The study demonstrated that combining outdoor learning with the STEAM approach offers a concrete opportunity to make primary school more inclusive, motivating and attentive to the overall well-being of students. The experimental intervention showed a significant impact on classroom climate, interpersonal relationships and motivation to learn, with particularly positive effects for students with autism spectrum disorder. This confirms the value of active methodologies in promoting educational equity and reducing gaps related to different learning styles, consolidating the idea that teaching can no longer be limited to transmitting content, but must create learning environments capable of valuing diversity and stimulating participation (Becker et al., 2017; Schunk & DiBenedetto, 2020). In line with studies conducted on inclusive outdoor motor and sports interventions for children with ASD (Morsanuto et al., 2023), the results of ' ' suggest that such practices should not be considered isolated experiences or limited experimental projects, but structural components of the curriculum.

Looking ahead, it will be important to extend the research to larger and more diverse samples, including schools from different socio-cultural contexts, in order to verify the transferability, adaptability and stability of the results over the long term. Further studies could also explore the impact of the outdoor STEAM approach on other educational dimensions, such as the development of digital skills, critical thinking and environmental awareness, which are increasingly central to the contemporary educational agenda (Bybee, 2020; Klein et al., 2022). At the same time, attention should be paid to the role of contextual variables, such as the socio-economic background of students, available local resources and the level of teacher

preparation, factors that significantly affect the effectiveness and sustainability of innovative practices (Hattie, 2021; Mercer-Mapstone et al., 2017).

Specific attention should also be paid to the professional skills required of teachers: managing experiential and interdisciplinary teaching contexts requires continuous training, flexible planning skills and a willingness to experiment with approaches that go beyond traditional classroom teaching (Leather & Thorburn, 2022). In order to make the adoption of methodologies such as outdoor STEAM systemic, it will therefore be necessary to integrate initial and in-service training courses capable of providing teachers with concrete tools to deal with the complexity of such practices.

The evidence that has emerged emphasises how education based on authentic, interdisciplinary and collaborative experiences can contribute substantially to building a more equitable, creative school capable of supporting the integral development of students (Faber-Taylor et al., 2022; Kozanitis & Nenciovici, 2023). Outdoor STEAM is therefore not only an innovative methodology, but a true educational paradigm capable of responding to the challenges of contemporary schools, geared towards promoting inclusion, well-being, sustainability and active citizenship. With this in mind, the school of the future should consider such approaches not as marginal alternatives, but as strategic levers for achieving an educational transformation capable of combining knowledge, doing and being in a dynamic and formative balance.

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