

Embodied Education and Artificial Intelligence: an integrated pedagogical model for the design of hybrid, inclusive and reflective learning environments in secondary schools

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Abstract: This study analyses the integration of the embodied approach and artificial intelligence in educational contexts, investigating their effects on engagement, intrinsic motivation and school inclusion. The research, conducted at two upper secondary schools in the city of Naples, involved 180 students divided into an experimental group and a control group according to a quasi-experimental design. The experimental group took part in an 8-week educational intervention based on embodied activities, collaborative practices and guided use of generative artificial intelligence tools, whilst the control group followed traditional teaching activities. The study adopted a mixed-methods approach, integrating the Student Engagement Scale (SES), the Intrinsic Motivation Inventory (IMI), semi-structured interviews and classroom observations. The results highlight a significant increase in engagement and intrinsic motivation within the experimental group, with preliminary positive indications also regarding the participation of students with special educational needs. The qualitative analysis further shows that AI-supported embodied activities fostered active participation, collaboration, multimodal accessibility and metacognitive reflection. Overall, the study suggests that the integration of embodied education and artificial intelligence, when supported by intentional pedagogical design, can contribute to the creation of more inclusive, reflective and participatory learning environments.

Keywords: Embodied Education; artificial intelligence; engagement; educational inclusion; hybrid learning environments



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1. Introduction

In recent years, the international educational debate has increasingly challenged learning models based on an exclusively cognitivist and disembodied conception of knowledge, highlighting the need to adopt theoretical perspectives capable of integrating the bodily, emotional, relational and situated dimensions of educational experience (Immordino-Yang, 2015). From this perspective, theories of embodied

cognition interpret learning not as an abstract process of symbolic processing, but as a phenomenon emerging from the dynamic interaction between body, environment, perception and action (Gallagher, 2017; Barsalou, 2020). Cognition is thus conceived as deeply rooted in sensorimotor processes, social participation and cultural mediation, overcoming the traditional separation between mind and body that has historically characterised much of pedagogical and psychological reflection.

Within this theoretical framework, learning takes on a situated, enactive and relational nature: processes of knowledge construction emerge through embodied practices in which perception, movement, emotion and social interaction jointly contribute to the production of meaning (Kiverstein & Miller, 2015; Gallagher, 2017). The body is not merely a biological support for cognition, but an active epistemic dimension through which individuals interpret, negotiate and transform experience. From this perspective, bodily, multimodal and collaborative activities can foster deeper, more reflective and lasting forms of learning, as they simultaneously engage cognitive, affective and participatory dimensions (Immordino-Yang et al., 2025).

At the same time, the growing prevalence of digital technologies and, in particular, generative artificial intelligence systems is significantly redefining the ways in which knowledge is accessed, produced and mediated in educational contexts (Holmes et al., 2019; Zawacki-Richter et al., 2019). Artificial intelligence, thanks to its ability to analyse data, generate content, adapt feedback and simulate linguistic interactions, introduces new possibilities for personalised learning, metacognitive support and the construction of interactive learning environments (Chen et al., 2020). However, these transformations cannot be interpreted solely in functional or technological terms. The growing integration of AI into educational processes raises epistemological, ethical and pedagogical questions regarding algorithmic transparency, bias, cognitive dependence, the delegation of decision-making and the progressive redefinition of educational agency (Selwyn, 2019; Williamson & Eynon, 2020). In the absence of intentional pedagogical design, there is a risk of promoting technocentric forms of learning, in which the complexity of the educational experience is reduced to mere interaction with automated systems.

Despite the growing scientific interest in the use of artificial intelligence in education, much of the literature continues to focus primarily on the performance-related, adaptive or automated aspects of intelligent technologies, neglecting the relationship between AI, embodiment, the relational dimension and inclusive participation. At the same time, studies on embodied learning often tend to focus on the sensorimotor and experiential dynamics of learning without systematically exploring the role of intelligent technologies as potential cognitive and

metacognitive mediators. This highlights a theoretical and empirical gap regarding the design of hybrid educational environments in which embodied experience and algorithmic mediation can coexist within a human-centred, inclusive and reflective pedagogical framework.

In this context, the perspective of the extended mind and distributed cognition takes on particular significance, according to which cognitive processes are not confined to the individual but unfold through dynamic networks involving the body, tools, environments and cultural artefacts (Clark, 2015; Heersmink, 2016). From this perspective, intelligent technologies can be interpreted as cognitive artefacts participating in knowledge-building processes, helping to redefine the boundaries between internal and external, between human and technological, and between individual cognition and distributed socio-technical systems (Floridi et al., 2018). AI is therefore not merely an operational support, but an element of a broader cognitive ecology, in which learning, technological mediation and educational relationships influence one another.

This perspective, however, requires a critical rethinking of contemporary pedagogical models. Whilst intelligent technologies can amplify embodied experience through immersive environments, adaptive feedback, simulations and multimodal practices (Radianti et al., 2020; Makransky & Petersen, 2021), there is also a need to preserve the centrality of human experience, reflexivity and the educational relationship. In this regard, the pedagogical value of AI does not lie in replacing teaching or automating learning processes, but in the possibility of supporting forms of cognitive, emotional and collaborative participation that are more inclusive, reflective and situated (Biesta, 2020).

The convergence of embodied education and artificial intelligence thus opens up an ecological and post-technocentric educational perspective, in which the body, technologies, environments and relationships dynamically co-construct learning processes. This configuration implies moving beyond a linear conception of digital teaching, favouring instead hybrid learning models based on multimodality, distributed agency, reflective mediation and embodied participation. Within this framework, the teacher assumes a crucial role in pedagogical orchestration, critical regulation and metacognitive facilitation, guiding the interaction between students, technologies and learning environments towards meaningful educational processes rather than merely performative ones.

Building on these theoretical premises, this study explores the integration of the embodied approach with artificial intelligence tools in secondary schools, with the aim of analysing their effects on student engagement, intrinsic motivation and inclusive participation within hybrid educational environments. In particular, the

research aims to contribute to the scientific debate on the design of human-centred educational ecosystems, offering empirical evidence and methodological guidelines useful for defining criteria and indicators for the Index for Embodied Education. The focus is primarily on the relationship between corporeality, technological mediation, inclusion, reflexivity and the co-construction of meaning, with a view to understanding how artificial intelligence can support, rather than replace, embodied, collaborative and socially situated learning processes.

2. Aims of the research

This study aims to investigate the integration of embodied approaches and artificial intelligence in the design of hybrid educational environments, with a particular focus on the transformations that such integration brings about in processes of participation, knowledge construction and pedagogical mediation. Drawing on the perspectives of embodied cognition, distributed cognition and the extended mind, the research interprets learning as a situated and multimodal process, co-constructed through the dynamic interaction between the body, technologies, relationships and educational contexts.

Within this theoretical framework, the study pursues three interrelated levels of objectives: exploratory, evaluative and design-oriented.

At the exploratory level, the research aims to understand how students and teachers perceive the integration of embodied practices and artificial intelligence tools in learning and teaching processes. In particular, the study analyses how AI is interpreted by students in terms of metacognitive support, reflective facilitation and cognitive scaffolding, or as a potential critical factor regarding autonomy, agency and the personal construction of knowledge. This dimension is situated within the contemporary debate on AI literacy and critical education regarding intelligent technologies, which highlights the need to develop forms of interaction that are conscious, reflective and non-dependent on algorithmic systems (Holmes et al., 2019; Long & Magerko, 2020).

Concurrently, from an evaluative perspective, the study aims to analyse the effects of AI-supported embodied activities on levels of engagement and intrinsic motivation among secondary school students. These dimensions are considered not merely as indicators of school participation, but as central components of meaningful, reflective and socially situated learning experiences (Fredricks et al., 2016; Bond et al., 2021). In particular, the research aims to investigate whether the integration of bodily practices, collaborative environments and AI tools can influence the behavioural, cognitive and emotional dimensions of engagement, fostering more active and intentional forms of participation in technologically mediated contexts.

A further evaluative dimension concerns the analysis of the inclusive potential of AI-supported embodied environments. The study aims to explore whether the combination of bodily activities, multimodal languages and intelligent technologies can foster more accessible and equitable forms of participation, particularly for students with special educational needs. From this perspective, inclusion is interpreted not as mere compensatory adaptation, but as an opportunity to broaden the modes of access, expression and shared construction of meaning through plural, flexible and multimodal educational ecosystems.

The research also aims to examine teachers' perspectives on the integration of embodied practices and algorithmic mediation, with particular reference to the methodological, organisational and ethical implications arising from the introduction of AI in school settings. From this perspective, the teacher's role is interpreted as one of pedagogical orchestration and critical regulation of learning processes, particularly in environments characterised by high technological complexity and communicative multimodality (Selwyn, 2019; Williamson & Eynon, 2020). The study therefore aims to explore how teachers redefine their professional practices in relation to processes of facilitation, reflective guidance and AI-supported educational mediation.

Finally, at the design level, the research aims to contribute to the definition of a transferable pedagogical model for the design of AI-supported embodied learning environments, oriented towards a human-centred rather than a technocentric perspective. The aim is to identify design, relational and methodological dimensions that may be useful for constructing future evaluation frameworks for Embodied Education, offering practical guidance for educational research, teacher training and pedagogical innovation.

Based on these objectives, the study is structured around the following research questions:

1. How does the integration of embodied activities and artificial intelligence tools influence students' engagement and intrinsic motivation in hybrid educational contexts?
2. How do students and teachers perceive the role of artificial intelligence in the processes of learning, participation and knowledge construction?
3. What inclusive implications emerge from the combined use of embodied practices, multimodal languages and AI tools for students with different learning profiles?
4. Which dimensions appear to be relevant for the design of AI-supported embodied environments from a human-centred perspective?

In this context, the work is situated within the framework of research that interprets educational environments as complex ecosystems, in which technologies, individuals, practices and contexts co-evolve through processes of embodied mediation, distributed cognition and social participation (Bower, 2019).

3. Methods

This study adopted a convergent mixed-methods design (Creswell & Plano Clark, 2017), aimed at integrating quantitative and qualitative evidence within a single interpretative framework geared towards understanding embodied learning processes supported by artificial intelligence. This methodological approach was chosen as it is particularly well-suited to investigating complex educational phenomena, characterised by the interaction between cognitive, bodily, emotional, relational and technological dimensions, which are difficult to interpret through a single methodological perspective.

The convergent approach involved the parallel collection of quantitative and qualitative data, subsequently integrated in the interpretative phase through methodological and conceptual triangulation (Fetters & Molina-Azorin, 2017). From this perspective, the quantitative component enabled the detection of any variations in levels of engagement and intrinsic motivation, whilst the qualitative component allowed for an in-depth exploration of the meanings attributed by participants to the educational experience, the pedagogical mediation practices, and the embodied dynamics that emerged during the intervention.

From an epistemological standpoint, the research is situated within a pragmatist and socio-constructivist perspective, according to which understanding educational processes requires the integration of different forms of empirical evidence and levels of analysis (Biesta, 2020). Consistent with this approach, the quasi-experimental design adopted was not aimed exclusively at measuring linear causal relationships, but at a situated understanding of the effects produced by the integration of embodied practices, technological mediation and the real educational context.

3.1. Research design and quantitative instruments

The study adopted a quasi-experimental pre-test/post-test design with an experimental group and a control group, using existing school classes. This methodological choice is consistent with applied educational research, in which organisational, ethical and institutional considerations frequently make the random allocation of participants impractical (Cohen et al., 2002). The use of natural groups made it possible to preserve the ecology of the school context and the continuity of educational dynamics, thereby enhancing the ecological validity of the study.

The quantitative component involved the use of standardised instruments that are widely validated in international educational research and consistent with the study's theoretical objectives.

To measure engagement, the Student Engagement Scale (SES) was used, comprising behavioural, cognitive and emotional dimensions, in line with multidimensional models of school engagement (Fredricks et al., 2016; Bond et al., 2021). The behavioural dimension concerned participation, attention and persistence in activities; the cognitive dimension explored learning strategies, self-regulation and mental investment; the emotional dimension investigated interest, belonging and the quality of the relational experience. The items were administered using a 5-point Likert scale (1 = 'not at all true'; 5 = 'completely true').

The Intrinsic Motivation Inventory (IMI) was used to measure intrinsic motivation, in line with Self-Determination Theory (Ryan & Deci, 2024). The instrument explored the sub-dimensions of interest/pleasure, perceived competence, effort/engagement, perceived value/usefulness, and tension/pressure. Responses were collected using a 7-point Likert scale (1 = 'not at all true'; 7 = 'very true'). Some items were reverse-coded in order to reduce the risk of response bias and improve the internal consistency of the instrument.

Both questionnaires were administered digitally in the pre-intervention and post-intervention phases by members of the research team in collaboration with the teachers involved, following standardised administration procedures designed to reduce contextual interference and procedural bias.

From a psychometric perspective, the instruments demonstrated satisfactory levels of internal reliability. Specifically, the SES reported a Cronbach's alpha coefficient of $\alpha = .88$ for the pre-test and $\alpha = .90$ for the post-test, whilst the IMI showed values of $\alpha = .91$ and $\alpha = .93$ respectively, indicating high internal consistency of the scales used.

3.2. Qualitative tools and triangulation procedures

The qualitative component was designed with the aim of exploring the participants' experiences in depth and interpreting the educational processes that emerged during the AI-supported embodied intervention.

Semi-structured interviews were conducted with students from the experimental and control groups, aimed at exploring perceptions, emotional experiences, modes of participation, collaborative experiences and representations of the use of artificial intelligence in learning processes. The adoption of the semi-structured format allowed for thematic consistency across the interviews, whilst leaving room for the emergence of personal narratives and subjective interpretations (Kallio et al., 2016).

In parallel, semi-structured interviews were conducted with the teachers involved in the experiment, aimed at exploring teaching strategies, educational mediation practices, methodological challenges, perceptions regarding the use of AI, and transformations in the teaching role within embodied and technologically mediated contexts.

To complement the interviews, systematic classroom observations were carried out and documented through structured field notes. The observations focused on participatory dynamics, collaborative interactions, body postures, the use of technology, modes of engagement and processes of co-construction of meaning that emerged during teaching activities. This procedure made it possible to capture contextual and relational aspects that are difficult to detect using standardised tools, facilitating a more ecological and situated understanding of educational processes. To strengthen qualitative reliability, triangulation procedures were adopted across sources, tools and interpretative perspectives. In particular, data from questionnaires, interviews and observations were systematically compared during the analytical phase, verifying interpretative convergences, divergences and complementarities. Furthermore, the qualitative coding was discussed collectively within the research team to reduce possible interpretative biases and improve analytical consistency.

3.3. Data analysis

The quantitative data were analysed using descriptive and inferential statistics. Means, standard deviations, percentage changes and comparisons between groups were calculated for the pre-test and post-test phases. Differences between the experimental group and the control group were analysed using t-tests for independent samples, in line with the quasi-experimental design adopted.

To strengthen the interpretation of the quantitative results, in addition to statistical significance, the effect size was also considered through the calculation of Cohen's *d*. In particular, for the results relating to overall engagement in the post-test, a high effect size ($d = 1.22$) was observed, indicating a substantial impact of the intervention on student engagement. Similarly, for intrinsic motivation, an effect size of $d = 1.08$ emerged, suggesting a significant effect of the intervention also in terms of motivation.

The qualitative data were analysed using thematic analysis according to the reflexive approach proposed by Braun and Clarke (2021). The analytical process comprised six main stages: familiarisation with the data, initial coding, identification of emerging themes, review of themes, conceptual definition of themes, and construction of the final interpretation. Coding was conducted iteratively, fostering a constant dialogue between empirical data, the theoretical framework and the

research objectives.

The integration of quantitative and qualitative data took place in the final phase of the analysis through a meta-inference procedure, aimed at constructing a multi-level interpretation of the educational experience. This integration made it possible to link the statistically detected variations in levels of engagement and motivation with the perceptions, embodied practices and relational dynamics that emerged from the interviews and observations. From this perspective, methodological triangulation helped to strengthen the interpretative validity of the study, offering a broader, situated and contextualised understanding of the educational impact resulting from the integration of the embodied approach and artificial intelligence.

4. Sample

The study was conducted at two upper secondary schools in the city of Naples, one specialising in the arts and the other in the classics. The sample comprised a total of 180 students aged between 13 and 15.

The choice of school settings was guided by an interest in investigating the integration of the embodied approach and artificial intelligence within educational environments characterised by a strong expressive, reflective and practical component. This configuration is consistent with contemporary perspectives on educational innovation in secondary school contexts and the need to develop multimodal and participatory learning environments (Selwyn, 2019).

The sample was divided into two groups: an experimental group involved in the AI-supported embodied intervention and a control group that continued with standard teaching activities using predominantly teacher-centred methodologies. Group allocation followed a quasi-experimental design, utilising existing classes and preserving the natural school organisation. Although this procedure does not allow for complete randomisation, it enabled the study to maintain high ecological validity and to observe the intervention in authentic educational settings.

The sample included a total of six students with special educational needs: two students with physical disabilities and four students with specific learning difficulties, including three cases of dyslexia and one case of dysorthographia, all duly certified in accordance with current legislation. The presence of these students allowed for a deeper exploration of the inclusive dimension of the proposed model, observing how embodied practices and AI tools can support different learning profiles.

The sample was selected through purposive non-probabilistic sampling, based on the willingness of educational institutions to participate in the research and the voluntary participation of students and families. In parallel, a convenience-based approach was also adopted, linked to the practical accessibility of the schools

involved. Although this configuration limits the statistical generalisability of the results, it is consistent with the exploratory and applied nature of the study.

Specific inclusion criteria were defined: voluntary participation in the study; informed consent from legal guardians; age between 13 and 15 years; enrolment at the participating schools; any special educational needs (SEN) certification; and participation in at least 50% of the scheduled activities. Students with prolonged absences, failure to participate in the pre/post-test assessments, or significantly incomplete questionnaires were excluded.

From an ethical standpoint, the research was conducted in accordance with the principles of the Declaration of Helsinki and current regulations on the protection of personal data. The anonymity of participants and the confidentiality of the information collected were guaranteed. All procedures were shared in advance with school leaders, teachers and families, in line with the ethical guidelines for educational research (Race & Vidal-Hall, 2019).

5. Activities

The educational programme took place outside school hours over a period of eight consecutive weeks, totalling 24 hours, organised into twice-weekly sessions lasting 90 minutes each. The decision to schedule the programme outside normal school hours allowed for greater organisational and methodological flexibility, facilitating the exploration of innovative teaching practices without interfering with the standard subject-specific curriculum. This approach is consistent with the literature highlighting the value of flexible educational spaces and workshop-based contexts in promoting pedagogical innovation and active student participation (Redecker, 2017).

The programme addressed the relationship between the body, identity and the expression of knowledge through an interdisciplinary approach centred on self-narration, bodily representation and the reworking of cultural, artistic and literary content. The main objective was to promote forms of meaningful, situated and reflective learning, emphasising the connection between bodily experience, the emotional dimension and cognitive construction (Immordino-Yang, 2015; Barsalou, 2020). From this perspective, the body was not regarded merely as a support for mental activity, but rather as a constitutive component of learning processes and the production of meaning (Gallagher, 2017).

For the control group, activities were structured according to a predominantly transmissive and teacher-centred approach, consistent with traditional teaching models still widely prevalent in secondary school settings (Kirschner & Hendrick, 2024). Students took part in lectures dedicated to the analysis of literary and artistic

texts relating to the themes of identity, personal expression and self-representation. The teaching activities included theoretical explanations, guided readings, text comprehension exercises, structured discussions and individual written assignments, such as short reflective essays and interpretative analyses.

In this setting, the teacher maintained a predominantly directive role in the transmission of knowledge and the management of activities, whilst collaborative peer interactions and physical experiences were limited. The use of digital technologies was marginal and primarily geared towards consulting materials or presenting content, without structured forms of interaction or co-construction of knowledge (Selwyn, 2019). Although these practices ensured continuity with standard teaching, they prioritised predominantly cognitive and verbal dimensions of learning, leaving embodied, relational and experiential aspects in the background.

The experimental group, on the other hand, took part in an innovative teaching programme based on a workshop-based, collaborative and embodied approach, geared towards the active participation of students and the enhancement of bodily experience in learning processes (Kiverstein & Miller, 2015; Gallagher, 2017). The activities were designed to simultaneously engage cognitive, emotional, relational and sensorimotor dimensions, fostering deep and contextualised processes of meaning-making.

In the initial phase of the programme, activities focusing on bodily activation and perceptual awareness were proposed, including spatial movement exercises, coordination practices, postural activities and non-verbal expression techniques. These activities aimed to stimulate attention, presence, participation and self-awareness, creating conditions conducive to embodied learning (Immordino-Yang, 2015). The physical practices were integrated with moments of guided reflection, designed to foster the connection between lived experience and cognitive processing.

Subsequently, students were involved in role-playing, dramatisation and narrative simulation activities, aimed at exploring personal experiences, emotional states and symbolic content linked to the themes addressed. In some sessions, students constructed and performed autobiographical narratives through bodily, performative and multimodal languages, using the body and voice as tools for cognitive and expressive mediation. These practices proved particularly effective in promoting experiential learning, reflection and active participation, in line with transformative models of education (Kolb, 2015; Biesta, 2020).

A central element of the intervention was also the use of tools based on generative artificial intelligence, employed as devices for cognitive, metacognitive and creative support. Students interacted with educational chatbots and writing

support systems based on linguistic models, used to develop ideas, formulate questions, obtain feedback, revise texts and critically reflect on their own narrative and argumentative work. The use of AI was conceived not as a replacement for the student's cognitive activity, but as a form of scaffolding capable of supporting reflective, creative and dialogic processes.

Interaction with the AI tools was constantly mediated by the teacher, who took on the role of critical facilitator and pedagogical regulator of the technological experience. In particular, teachers guided students in verifying the information generated, in collective discussion of the responses produced by the intelligent systems, and in the personal reworking of content, promoting forms of conscious, reflective and non-technocentric use of artificial intelligence. This approach is consistent with perspectives that interpret intelligent technologies as cognitive artefacts embedded in systems of distributed cognition and the extended mind (Clark, 2015; Heersmink, 2016), whilst maintaining the relational and intentional dimension of the educational experience as central.

The activities of the experimental group were mainly carried out in small groups, fostering collaborative dynamics, the negotiation of meanings and the co-construction of knowledge – fundamental elements in contemporary social-constructivist models (Ou, 2024). The students produced multimodal outputs such as narrative performances, integrated presentations, digital projects and audiovisual narratives, combining bodily, expressive and technological languages. This integration fostered the development of cross-curricular skills related to creativity, collaboration, communication and critical reflection (Bower, 2019).

From a structural perspective, the intervention was divided into three main phases. The first phase involved activating prior knowledge, introducing the course themes and fostering a relational climate conducive to participation. The second phase, of a workshop-based and experiential nature, formed the core of the intervention and was characterised by the integration of embodied activities, collaborative practices and the use of artificial intelligence. The third phase was dedicated to metacognitive processing and the final presentation of the work, through sessions of presentation, group discussion and shared reflection on the experiences undertaken. The inclusion of structured moments of reflection proved particularly significant in fostering processes of awareness, consolidation of learning and the attribution of meaning to the educational experience.

Overall, the design of the intervention allowed for a systematic comparison of two different teaching models: on the one hand, a predominantly transmissive approach centred on the cognitive dimension; on the other, an embodied, collaborative and technologically mediated model, geared towards valuing physicality,

active participation and critical reflection. This comparison has enabled us to explore the educational potential arising from the integration of embodied experience and artificial intelligence, contributing to the definition of innovative, inclusive and sustainable pedagogical practices in contemporary educational contexts (Miao & Holmes, 2021).

6. Results

6.1. Quantitative results

The quantitative analysis was conducted in line with the study's mixed-methods and quasi-experimental design, with the aim of comparing the outcomes of the experimental group and the control group in terms of levels of engagement and intrinsic motivation as measured by the *Student Engagement Scale* (SES) and the *Intrinsic Motivation Inventory* (IMI). Prior to the inferential analyses, the internal reliability of the instruments used was verified. The internal consistency coefficients showed satisfactory values: $\alpha = .88$ for the SES and $\alpha = .91$ for the IMI, indicating good overall reliability of the scales in the context of the study.

In line with the research design, the data were subjected to descriptive analysis (means and standard deviations) and inferential analysis using the *t-test* for independent samples, in order to verify any statistically significant differences between the groups in the pre- and post-intervention phases. For the main differences emerging in the post-test, the effect size was also calculated using Cohen's *d* coefficient, in order to estimate the practical magnitude of the observed effects.

The pre-test results do not show any statistically significant differences between the experimental group and the control group, suggesting substantial initial homogeneity of the sample with respect to the variables considered. With regard to overall engagement (SES), the experimental group reported a mean of $M = 3.45$ ($SD = 0.50$), whilst the control group recorded $M = 3.23$ ($SD = 0.48$), with a non-significant difference, $t(178) = 1.87$, $p > .05$. Similarly, for intrinsic motivation (IMI), the experimental group scored $M = 4.70$ ($SD = 0.72$), compared to $M = 4.48$ ($SD = 0.69$) for the control group, with no statistically significant differences, $t(178) = 1.65$, $p > .05$. These results confirm the initial comparability of the two groups and reinforce the internal validity of the subsequent comparison.

In the post-test, however, statistically significant differences emerged in favour of the experimental group with regard to both engagement and intrinsic motivation. With regard to overall engagement (SES), the experimental group reported $M = 4.12$ ($SD = 0.48$), a value significantly higher than that of the control group ($M = 3.45$;

$SD = 0.52$), with $t(178) = 8.21$, $p < .001$. The effect size was large (Cohen's $d = 1.24$), suggesting a substantial impact of the intervention on students' participatory dynamics. In percentage terms, the experimental group showed an average increase of 19.4% compared to baseline levels, whilst the control group recorded a more modest increase of 6.8%.

Analysis of the individual dimensions of engagement reveals particularly high results in the emotional component of the experimental group ($M = 4.25$; $SD = 0.44$), followed by the behavioural ($M = 4.10$; $SD = 0.50$) and cognitive ($M = 4.02$; $SD = 0.47$) dimensions. These data suggest that the combination of embodied activities, collaborative learning and technological mediation has influenced not only students' active participation, but also their affective engagement and sense of belonging to the educational experience. The control group, by contrast, reported lower scores across all dimensions considered, with relatively higher results in the behavioural component ($M = 3.60$; $SD = 0.51$), but significantly lower scores in the emotional ($M = 3.38$; $SD = 0.49$) and cognitive ($M = 3.37$; $SD = 0.53$) dimensions.

Similar results emerge regarding intrinsic motivation (IMI). The experimental group recorded an overall mean of $M = 5.62$ ($SD = 0.71$), significantly higher than the control group ($M = 4.78$; $SD = 0.76$), with $t(178) = 7.34$, $p < .001$. Here too, the effect size is high (Cohen's $d = 1.06$), highlighting a significant impact of the intervention on the motivational quality of the learning experience. In particular, the sub-dimensions of interest/pleasure ($M = 5.85$; $SD = 0.68$) and perceived value/usefulness ($M = 5.70$; $SD = 0.72$) appear significantly higher in the experimental group than in the control group (respectively $M = 4.90$; $SD = 0.75$ and $M = 4.85$; $SD = 0.73$). This evidence seems to indicate that the AI-supported embodied activities were perceived by the students as more meaningful, engaging and personally relevant.

The data relating to students with special educational needs (SEN) are also particularly significant. In the pre-test, the recorded values appear substantially similar between the two groups: the experimental group reported an average engagement score of $M = 3.30$ ($SD = 0.52$), whilst the control group recorded $M = 3.18$ ($SD = 0.50$). Similarly, for intrinsic motivation, the experimental group achieved $M = 4.40$ ($SD = 0.68$), compared to $M = 4.32$ ($SD = 0.66$) for the control group.

In the post-test, the SEN students in the experimental group showed a greater increase in levels of engagement and intrinsic motivation compared to the control group. In particular, engagement reached $M = 3.95$ ($SD = 0.51$) in the experimental group, compared to $M = 3.30$ ($SD = 0.55$) in the control group. Similarly, intrinsic motivation recorded values of $M = 5.30$ ($SD = 0.65$) in the experimental group,

compared to $M = 4.50$ ($SD = 0.70$) in the control group. Whilst taking into account the small size of the SEN sub-sample and the consequent need for caution in interpretation, these data suggest that the intervention fostered more accessible and inclusive conditions for participation, thanks to the variety of languages used, the multimodal nature of the activities, and the possibility of integrating cognitive and compensatory support tools.

In percentage terms, students with SEN in the experimental group showed an average increase of 17.2% in engagement levels and 14.8% in intrinsic motivation, whilst in the control group these increases stood at 5.9% and 6.3% respectively. These findings appear consistent with inclusive approaches that emphasise methodological flexibility, multimodality and the diversification of expressive channels as conditions that facilitate the participation of students with different learning profiles (Florian, 2017).

Overall, the quantitative results highlight how the intervention, based on the integration of an embodied approach and the reflective use of artificial intelligence, produced positive and statistically significant effects on levels of engagement and intrinsic motivation. In line with the mixed-methods design adopted, this quantitative evidence is further explored and interpreted through qualitative data, which allows us to understand not only the extent of the observed effects, but also the ways in which the body, relationships, collaboration and technological mediation have contributed to the construction of more participatory, inclusive and meaningful educational experiences.

6.2. Qualitative results

The analysis of the qualitative data was carried out using a thematic analysis process, aimed at exploring in depth the perceptions of students and teachers regarding the activities undertaken, the role of the body in learning processes, and the integration of artificial intelligence into teaching. The analysis of semi-structured interviews and classroom observations identified several recurring themes, highlighting significant differences between the experimental group and the control group.

A key theme concerns student engagement and active participation. Students in the experimental group described the experience as more dynamic, participatory and aligned with their own learning styles. Many participants emphasised how physical engagement had fostered attention, concentration and motivation. One student stated: “I felt more part of the lesson; I didn’t just have to listen but do something with my body and with others.” Another said: “When we represented emotions through movement, I understood better what we were studying.” These accounts

suggest that embodied activities facilitated processes of situated understanding and experiential construction of meaning.

Teachers in the experimental group also confirmed this perception, highlighting an increase in students' active participation and emotional engagement: "The students seemed more engaged because the activity required them to act, interpret and collaborate"; "I noticed a greater willingness to get involved, even from pupils who are usually more reserved." Classroom observations also highlighted a higher frequency of spontaneous interactions, peer cooperation and voluntary participation in workshop activities.

In the control group, by contrast, students' opinions indicated participation that was perceived as more passive and less experiential. Some students stated: "The lessons were clear, but we often just sat there listening and taking notes"; "I understood the texts, but I would have liked to do something more practical". Teachers in the control group acknowledged the greater organisational linearity of traditional teaching, but also a reduced ability to engage students on a participatory and emotional level: "Lecture-style teaching allows the curriculum to be followed in an orderly manner, but it does not always manage to involve everyone" ; "Some students participate, others remain more passive and only speak up when prompted".

A second key theme concerns the perception of artificial intelligence as a support for learning processes. Students in the experimental group generally described AI as a useful tool for organising ideas, receiving feedback and revising content. Some participants stated: "The chatbot helped me find a different way to start the text"; "It didn't do the work for me, but it gave me suggestions on how to improve it". The testimonies gathered suggest that AI was predominantly perceived as a tool for reflective support rather than a substitute for personal cognitive work.

Teachers in the experimental group also highlighted the value of AI in promoting processes of revision and critical reflection: "Students did not simply accept the system's responses, but learnt to discuss and modify them"; "Artificial intelligence was useful when it became an opportunity to reflect on choices, not just to produce a text". These observations confirm the importance of pedagogical mediation in transforming the use of AI into a metacognitive and critical experience.

At the same time, some concerns also emerged regarding the reliability and quality of content generated by intelligent systems. Some students highlighted difficulties in distinguishing relevant suggestions from overly generic or standardised answers: "Sometimes the chatbot gave useful ideas, other times the answers all seemed the same"; "We still had to check because what it wrote wasn't always suitable for the task". Similarly, some teachers expressed concerns regarding the risk

of cognitive dependency and the automated delegation of thought processes: “Without strong pedagogical guidance, some students tend to accept the answers without critically re-evaluating them”; “AI can be useful, but we need to educate students to discuss and verify the content produced”.

These points are particularly significant as they confirm the need to integrate artificial intelligence into reflective, non-technocentric educational practices, in which the teacher maintains a central role in the critical mediation of learning processes and in the development of students’ epistemic autonomy.

A further thematic focus concerns the inclusive dimension of the intervention and the experience of students with special educational needs. Students with SEN in the experimental group reported greater accessibility to the activities thanks to the presence of diverse modes of expression—physical, visual, oral and digital. A student with a learning disability stated: “When I could explain things using images and movement as well, I felt less challenged than when writing.” Another said: “AI helped me check the text, and this made me feel more confident.” Students with physical disabilities also highlighted the value of adapted participation: “Not all activities were the same for everyone, but I could still participate in my own way”.

Teachers in the experimental group also emphasised the inclusive value of the approach adopted: “The possibility of using different forms of expression allowed students with difficulties to demonstrate skills that are less apparent in traditional teaching”; “Physical and multimodal activities reduced the emphasis on written performance, promoting more equitable participation.” Classroom observations confirmed greater participation by SEN students in collaborative and performance-based activities compared to purely text-based activities.

In the control group, however, SEN students reported greater difficulties linked to the prevalence of reading and written production: “When there were lots of texts to read, I found it harder”; “I needed more time to write and sometimes felt I was lagging behind the others”. Teachers also acknowledged certain shortcomings of traditional teaching with regard to the personalisation of learning pathways: “Students with SLDs often need more time and compensatory tools, but in a standard lesson it is not always easy to personalise”.

A further key theme concerns the transformation of the educational relationship and the teacher’s role. Teachers in the experimental group described their role as being more focused on facilitation, mediation and reflective guidance. One teacher observed: “During embodied activities, I saw students who were usually more passive become active participants.” Another teacher stated: “AI worked when it was embedded within a clear pedagogical framework; without the teacher’s guidance, it risks becoming merely a technical tool.” The students

confirmed this perception, describing the teacher as a figure providing support and pedagogical direction: “The teacher didn’t just explain, but helped us understand what we were doing”; “They also guided us when we used AI, encouraging us to reflect on our answers.”

In the control group, the teacher was predominantly perceived as the main source of explanation and assessment: “The teacher explained and then we did the exercises”; “Everything was clear, but there was less opportunity to work creatively”. Although this approach was associated with organisational clarity and control over content, the students highlighted fewer opportunities for active participation, creativity and collaboration.

Finally, another key theme concerns peer collaboration. In the experimental group, small-group activities, performances and digital storytelling fostered cooperative dynamics and processes of co-constructing knowledge. The students stated: “Working with others helped me to see ideas different from my own”; “In the performance, everyone had a role, and this made us feel part of a shared project”. Teachers highlighted how such activities fostered shared responsibility, the negotiation of meanings and the enhancement of individual skills.

In the control group, however, collaboration proved more limited and sporadic: “We discussed some texts together, but then the work was almost always individual.” Teachers also confirmed that most activities required individual performance and were predominantly teacher-centred.

Overall, the qualitative analysis confirms and elaborates on the findings that emerged from the quantitative data. The experimental group demonstrated a perception of learning more closely associated with active participation, a diversity of languages, reflexivity, inclusion and the critical use of artificial intelligence. At the same time, a shift in the teacher’s role emerges, from that of a content transmitter to a facilitator of embodied experiences and a pedagogical mediator of technologies. The control group, on the other hand, reported an experience perceived as more linear and structured in terms of content, but less engaging from a physical, collaborative and experiential perspective.

7. Discussion

The results of the study suggest that the integration of an embodied approach with artificial intelligence may represent not only an innovative methodological strategy, but a genuine epistemological reconfiguration of the educational experience. The comparison between the experimental group and the control group highlights, in fact, how learning environments based on multimodality, bodily participation, reflective mediation and the critical use of AI are capable of significantly influencing

processes of engagement and intrinsic motivation. This evidence confirms theoretical perspectives that interpret learning as a situated, relational and embodied process, in which cognition, emotion, corporeality and social interaction operate interdependently (Gallagher, 2017; Immordino-Yang et al., 2025; Barsalou, 2020).

The most significant aspect emerging from the research probably concerns the qualitative nature of the engagement observed in the experimental group. The results do not merely indicate a quantitative increase in participation, but suggest a transformation in the ways in which students engage with knowledge. In particular, the sharp increase recorded in the emotional dimension of engagement seems to indicate that embodied practices have fostered more authentic, intentional and meaningful forms of participation. Bodily engagement, dramatisation, storytelling and cooperation did not act as mere ancillary motivational strategies, but as epistemic devices through which students were able to construct, represent and negotiate the meaning of subject content.

From this perspective, the results appear consistent with embodied and enactive perspectives that conceive of knowledge as emerging from the dynamic interaction between body, environment and social relations (Kiverstein & Miller, 2015). Within the experimental programme, the body does not appear to have performed a merely expressive or performative function, but rather a cognitive and interpretative one. The bodily and multimodal activities have, in fact, enabled students to transform abstract concepts into situated, shared and negotiable experiences, fostering deeper processes of understanding compared to those observed in the control group, which was characterised predominantly by transmissive and teacher-centred practices.

In this context, artificial intelligence takes on a particularly interesting role from a pedagogical and epistemological perspective. The results show, in fact, that AI did not produce significant effects simply as a technology, but rather as an element integrated within an embodied and relational learning ecosystem. This finding appears theoretically relevant, as it suggests that the educational value of intelligent technologies does not depend on their automated capabilities, but rather on the quality of the pedagogical practices that guide their use. During the experimental study, generative chatbots and writing support tools were perceived by students as devices for cognitive and metacognitive scaffolding, useful for organising ideas, reflecting on content, revising drafts and critically examining the responses received.

Such evidence appears to engage meaningfully with the perspectives of the extended mind and distributed cognition (Clark, 2015; Heersmink, 2016), according to which technological tools and artefacts can participate in cognitive processes when incorporated into intentional and socially situated practices. The study's

findings therefore suggest that AI can be interpreted not as a substitute for human cognitive activity, but as a mediating artefact capable of expanding reflective, metacognitive and collaborative processes. From this perspective, learning emerges as a phenomenon distributed across the body, technologies, the environment and educational relationships, within hybrid and dynamic cognitive configurations.

At the same time, the research clearly highlights the ambivalences that characterise the introduction of AI in educational contexts. The critical issues that emerged in the interviews — relating to the standardisation of responses, the risk of cognitive dependency and automated delegation — show that intelligent technologies do not automatically produce educational innovation. On the contrary, the results confirm the critical positions found in the international literature (Selwyn, 2019; Williamson & Eynon, 2020), according to which the pedagogical effectiveness of AI depends on the presence of strong educational mediation capable of preserving students' agency, epistemic autonomy and critical reflexivity. In the absence of such mediation, there is a risk that technology will reduce the complexity of learning to mere functional interaction with automated systems.

In this regard, one of the study's most significant theoretical contributions concerns the redefinition of the teacher's role in AI-supported educational contexts. The qualitative findings show that teachers in the experimental group progressively took on roles involving pedagogical orchestration, reflective facilitation and critical regulation of learning processes. Teachers' professionalism does not, therefore, appear to be diminished by the introduction of AI, but rather transformed. The teacher emerges as a central figure in the construction of pedagogical frameworks capable of integrating the body, technologies and the educational relationship in a coherent and meaningful way. This implies a shift from a predominantly transmissive role to an ecological and mediating role, oriented towards the design of complex, multimodal and participatory learning environments.

The inclusive dimension that emerged from the research is also particularly significant. Students with special educational needs reported higher levels of engagement, motivation and perceived accessibility within the experimental group, suggesting that the combination of embodied activities, multimodal languages and AI tools may foster more equitable and flexible conditions for participation. This result appears consistent with inclusive perspectives that interpret accessibility not as mere individual compensation, but as the design of educational ecosystems capable of broadening the possibilities for expression, participation and the shared construction of meaning (Florian, 2017). The AI-supported embodied approach therefore seems to contribute to reducing the exclusive centrality of written performance, valuing different cognitive, expressive and relational modalities.

Overall, the results suggest that the effectiveness of the experimental model does not stem from isolated individual elements — embodiment, collaboration or technology — but from their coherent integration within a unified pedagogical ecosystem. Educational innovation does not therefore appear to stem from the simple digitisation of teaching, but rather from the ability to rethink learning environments as embodied, relational, multimodal and reflective spaces. From this perspective, the convergence of embodied education and artificial intelligence helps to outline a human-centred and post-technocentric educational framework, in which technology is subordinated to the quality of the educational experience and the pedagogical relationship.

In light of the findings, the study also allows us to hypothesise some preliminary theoretical and methodological dimensions useful for the construction of a possible *Index for Embodied Education*. Among the most relevant indicators are:

- multimodal integration of languages;
- active bodily participation;
- reflective mediation by the teacher;
- multimodal accessibility;
- distributed collaboration;
- critical and non-substitutive use of smart technologies;
- centrality of the educational relationship;
- promotion of epistemic autonomy;
- integration of experience, reflection and metacognition.

These dimensions are not merely operational indicators, but constitute a possible theoretical framework for interpreting contemporary hybrid educational environments as embodied and cognitively distributed ecosystems. From this perspective, the study's contribution concerns not only the evaluation of a specific educational intervention, but the proposal of a broader pedagogical approach, aimed at critically rethinking the relationship between the body, cognition, smart technologies and the social construction of knowledge.

7.1. Limitations of the study and future prospects

Although the findings highlight the pedagogical potential of integrating an embodied approach with artificial intelligence, the study has certain methodological and contextual limitations that call for caution in interpretation. Firstly, the sample was selected using a non-probabilistic, purposive and convenience-based procedure, limited to two upper secondary schools in the city of Naples. Whilst consistent with the exploratory and applied nature of educational research, this design limits the

possibility of generalising the results to other school contexts, levels of education or different socio-cultural settings.

A further critical issue concerns the small size of the subgroup of students with special educational needs. Although the quantitative and qualitative data suggest positive effects in terms of accessibility, participation and motivation, the limited number of SEN participants does not allow for generalisable conclusions regarding the model's inclusive effectiveness. Future studies with larger and more heterogeneous samples will therefore be necessary to explore the impact of AI-supported embodied practices on different cognitive, relational and neurodivergent profiles.

The relatively short duration of the intervention also represents a significant limitation. The eight-week trial allowed for the observation of significant variations in levels of engagement and intrinsic motivation, but does not permit verification of the stability of these effects in the long term, nor the possible consolidation of reflective, collaborative and metacognitive skills. In this regard, it appears particularly important to develop longitudinal research capable of monitoring, over time, the processes of educational transformation generated by the integration of embodiment, technological mediation and collaborative practices.

Further challenges relate to the difficulty of fully controlling contextual variables typical of real school settings, such as classroom dynamics, methodological differences between teachers, students' initial motivation and varying levels of familiarity with digital technologies. Consistent with the ecological and situated perspective adopted in the study, these variables were not artificially eliminated but considered an integral part of the observed educational complexity. However, they represent elements that may influence the outcomes of the intervention and require further methodological investigation.

From a theoretical and design perspective, the study also proposes some preliminary dimensions useful for the construction of a possible *Index for Embodied Education*. Although these indicators emerge consistently from the empirical results and the theoretical framework adopted, they require subsequent scientific validation procedures, both at the theoretical level and at the psychometric and operational levels. Future studies will therefore need to verify the reliability, transferability and applicability of the model in different educational contexts, with a view to transforming these dimensions into a structured and methodologically robust evaluation framework.

In light of these considerations, the future prospects for research appear particularly broad. It is necessary to develop comparative and longitudinal studies involving different school levels, socio-cultural contexts and teaching configurations,

exploring the relationship between embodied education, artificial intelligence, inclusion and distributed cognition. At the same time, it is essential to investigate the professional skills required of teachers to design and manage AI-supported embodied educational environments, so as to better understand the pedagogical, ethical and organisational conditions necessary for a truly sustainable integration of intelligent technologies into contemporary education systems.

8. Conclusion

This study has highlighted how the integration of an embodied approach with artificial intelligence can contribute to the creation of educational environments that are more participatory, reflective and inclusive. The quantitative and qualitative results show that the experimental group experienced more active and meaningful forms of learning, in which bodily experience, relationships, collaboration and technological mediation functioned as interdependent dimensions of the educational process. Learning was not configured exclusively as the acquisition of content, but as a situated experience of shared meaning-making.

One of the most significant elements to emerge from the research concerns the pedagogical role of artificial intelligence. The results suggest that AI produces educationally significant effects not when it is used as a substitute or automated device, but when it is integrated within embodied, collaborative and metacognitive practices. From this perspective, intelligent technologies appear to function as cognitive artefacts capable of supporting reflection, scaffolding and the personalisation of learning pathways, provided their use is consistently guided by intentional and critical pedagogical design.

The inclusive dimension of the experimental model also appears particularly significant. The combination of physical activities, multimodal languages and AI tools has fostered more accessible conditions of participation for students with special educational needs, reducing the exclusive focus on written performance and broadening the possibilities for expression and knowledge construction. Such evidence reinforces the idea that AI-supported embodied environments can contribute to the design of more equitable, flexible and human-centred educational ecosystems.

Although the results must be interpreted in light of the methodological limitations discussed in the previous section, the study offers significant preliminary evidence regarding the educational potential of integrating an embodied approach with artificial intelligence in contemporary school contexts. Looking ahead, it is necessary to expand the research through longitudinal and comparative studies capable of verifying the model's transferability across different school levels and

educational contexts. Further lines of inquiry could explore the role of AI in metacognitive processes, digital storytelling, collaborative writing and the development of students' epistemic autonomy. In parallel, it appears particularly relevant to analyse the professional skills required of teachers to design and manage AI-supported embodied environments, so as to better understand the pedagogical, organisational and ethical conditions necessary for a truly sustainable integration of intelligent technologies.

On a theoretical level, the study's main contribution lies in proposing an integrated interpretation of the relationship between embodied education, distributed cognition and artificial intelligence within hybrid educational environments. The results suggest that educational innovation cannot be reduced to a simple process of digitising teaching, but requires an ecological rethinking of the relationships between body, mind, technologies and learning contexts. From this perspective, AI does not replace the educational experience, but can amplify its participatory, reflective and transformative potential when embedded in pedagogical ecosystems oriented towards relationship, multimodality and the shared construction of knowledge.

Finally, the dimensions that emerged from the research — embodied participation, multimodality, reflective mediation, accessibility, distributed collaboration and the critical use of AI — offer preliminary guidelines for the construction of a possible *Index for Embodied Education*. These elements could form the basis for future theoretical and evaluative frameworks aimed at interpreting and designing human-centred educational environments in contemporary technology-mediated contexts.

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