International Journal of Arts and Social Science www.ijassjournal.com
ISSN: 2581-7922,
Volume 9 Issue 7, July 2026

Challenges and Responses of Embodied Cognition Theory in Education in the Era of Artificial Intelligence

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Abstract: The deep integration of artificial intelligence and education poses challenges to bodily experience in the learning process. Based on embodied cognition theory, current education faces threefold dilemmas: at the knowledge level, the detachment of bodily experience and lack of feedback; at the subject level, the obscuring of bodily participation in teacher and student roles; and at the environmental level, the disembodiment of educational interactions. These dilemmas stem from the four-dimensional conflicts between "disembodied" technical rationality and "embodied" educational logic (purpose, process, relationship, evaluation), as well as from the difficulty of capturing tacit bodily experience and the dissolution of embodied relationships in virtual teaching environments. The solutions lie in precisely responding to these conflicts: at the knowledge level, replacing single information transmission with a closed loop of "virtual demonstration + real experience"; at the subject level, demarcating human-machine boundaries to allow teachers to return to emotional interaction and bodily demonstration, and students to rebuild subjectivity through "AI-free periods"; at the value level, establishing a humanistic evaluation system centered on "bodily participation" and "quality of emotional connection" to set ethical red lines for technology application.

Keywords: artificial intelligence; embodied cognition; technical rationality; bodily experience

I. Introduction

Artificial Intelligence (AI) is rapidly reshaping the landscape of education. According to 2025 data from the Ministry of Education of China, the National Smart Education Platform has surpassed 164 million registered users, and the proportion of primary and secondary school teachers applying AI has risen to 81%, covering core instructional stages such as lesson preparation, teaching, and assessment (Chen, 2018). AI has shifted from a mere auxiliary tool to a significant driver of educational transformation. While improving teaching efficiency, it has also raised a fundamental question: when the learning process is reduced to data input and algorithmic feedback,

what remains of students' bodily experience (Chen, 2025)? Traditional cognitive views regard cognition as abstract information processing, with the body merely a carrier of the mind, and education is simplified into efficient input and processing of information (Wang et al., 2025). Embodied cognition theory, in contrast, argues that cognition arises from bodily action, and that memory, thinking, and learning are intimately connected with physical activity. Although AI empowers education, because it lacks a human body, it carries an inherent tendency toward "disembodiment" (Yang et al., 2025). Therefore, against the backdrop of the accelerating integration of AI and education, re-examining the status and dilemmas of bodily experience in teaching has become an unavoidable theoretical issue for educational development in the intelligent era.

However, existing research has largely focused on the application efficacy of AI in personalized learning, intelligent tutoring systems, and big data analytics in education, with few studies systematically examining the issue of "bodily experience" in AI-driven education from the perspective of embodied cognition (Wang et al., 2025). Memarian and Doleck's systematic review also found that algorithmic precision and technical performance dominate research attention, while learners' bodily needs receive little consideration (Memarian & Doleck, 2024). Existing studies have not yet systematically revealed the internal mechanisms of the bodily-experience dilemmas in AI-era teaching, nor have they analyzed them from the fundamental conflict between "disembodied" technical rationality and "embodied" educational logic. To address this gap, this paper draws on embodied cognition theory to reveal the threefold dilemmas of bodily experience in AI-era teaching, analyzes their deep-seated causes – especially the four-dimensional conflicts between technical rationality and educational logic (purpose, process, relationship, evaluation) – and proposes pathways for returning to embodied experiences by precisely responding to these conflicts.

II. Embodied Cognition: An Educational Logic Centered on the Body

Before exploring why bodily experience in AI-era teaching faces dilemmas, we must first clarify a fundamental question: what role does the human body play in cognition and learning? In the traditional cognitive science perspective, the body has long occupied a marginal position. Cognition is regarded as abstract information processing detached from the body; the body is merely a receiver of sensory signals and an executor of behavioral commands, not a subject of cognitive activity. This "disembodied" paradigm has profoundly influenced educational practice, reducing knowledge transmission to one-way information flow from teacher to student, while students' bodily experience, emotional fluctuations, and situational interactions are treated as "interference" rather than integral components of cognition (Ye, 2019).

Since the 1980s, however, an "embodied revolution" has emerged in cognitive science. The core claim of embodied cognition theory can be summarized as: cognition is not disembodied mental activity but is rooted in the body's structure, sensorimotor experience, and real-time interaction with the environment (Ye, 2023). This position comprises three progressive levels. First, the body constitutes the vehicle of cognition. Human perceptual, memory, thinking, and emotional processes are all influenced by the body's anatomical structure, sensorimotor system, and bodily states. For example, fine finger movements can facilitate mathematical cognitive development,

and body posture and facial expressions can reciprocally shape emotional experience. Second, the body generates cognitive content. The formation of abstract concepts often originates from the body's interactive experience with the world. People understand "time" through spatial orientation ("front"/"back") and "emotion" through temperature sensation ("warm"/"cold"); the source of these metaphorical mappings is bodily experience. Third, the body is embedded in the cognitive situation. Cognition does not occur in isolation inside the head but unfolds dynamically in specific physical and social contexts. Learners interact with the environment through bodily actions (manipulation, experimentation, performance, writing), generating new understandings in the process (Jiao, 2020).

Compared with the disembodied cognitive paradigm, embodied cognition theory aligns more closely with the logic of human development in education. The "logic of human development" refers to the fact that, as a practical activity cultivating "whole persons," education's core goal is not to train "rational machines" that efficiently process symbolic information, but to awaken living individuals with subjective agency, emotional experience, value judgment, and creative capacity. This logic imposes three basic requirements on education, all of which can only be fulfilled through bodily presence.

First, emotional contagion relies on bodily co-presence. Education is not only the transmission of knowledge but also the resonance of emotions and the inheritance of values. Teachers' passion, care, trust, and students' curiosity, confusion, and joy cannot be completely conveyed through data streams or written symbols; they require face-to-face eye contact, tone changes, gestures, and even subtle physical distance. As Ye (2019) stated, the "teaching by words and examples" between teacher and student is essentially a dialogue between bodies; the teacher's charisma permeates students' hearts through bodily demonstration (Kennedy et al., 2024). Second, meaning generation depends on bodily trial and error. Human learning is not linear accumulation of information but is filled with nonlinear processes such as trial-and-error, insight, and reflection. When students manipulate experiments, repeatedly practice movements, or gesticulate animatedly in discussions, they are constructing their own understanding through bodily participation (Zhang et al., 2026). This understanding is tacit – students may not be able to articulate clearly how they have mastered a skill or intuition, but their body knows. Standardized instruction under the disembodied paradigm attempts to skip this "inefficient" trial-and-error phase, which runs counter to the laws of cognitive generation (Su & Ye, 2025). Third, the awakening of subjectivity relies on autonomous bodily action. Human subjectivity is not bestowed but generated in action. Only by solving problems with their own hands, making choices in real situations, and collaborating with peers to meet challenges can students gradually develop confidence in their own abilities and a sense of responsibility toward the world (Shi & He, 2025). All these actions require active bodily participation. If the learning process is reduced to watching videos, clicking options, and receiving feedback, the student's body becomes a passive receiving terminal and subjectivity cannot grow (Wang, 2020).

In summary, embodied cognition theory not only revises traditional cognitive science but also provides a theoretical framework highly congruent with the logic of human development in education. It reminds us that any educational technology that attempts to exclude the body from the cognitive process, no matter how efficient,

carries the risk of "dehumanization." Based on this theoretical stance, the following sections systematically examine the specific dilemmas of bodily experience in teaching after AI intervention and reveal the deep-seated causes of these dilemmas.

III. Dilemmas of Bodily Experience in Teaching in the AI Era

III. 1 The Knowledge Level: Absence of Bodily Experience in Cognitive Construction

III. 1.1 Detachment of Bodily Experience in Knowledge Transmission

AI-driven teaching models are characterized by "disembodied" knowledge transmission (Chen, 2018): knowledge is presented in symbolic, abstracted forms, stripped of concrete physical situations and bodily interactions. The teaching process is reduced to one-way visual and auditory reception, and the student's body becomes a passive terminal rather than an active constructor of knowledge (Yang et al., 2025). According to embodied cognition theory, cognition is rooted in sensorimotor experience, and knowledge generation depends on body-environment interaction (Yuan & Li, 2025). However, in AI-based instruction, such bodily experience steps are often replaced (Luo et al., 2023). For example, students learning "acceleration" through a video see only formulas and animations; if they could time themselves running on the playground and feel the speed change with their bodies, their understanding would be much deeper. Lacking bodily perception, knowledge remains at an abstract level and is difficult to transfer to real-world situations. Skill-based knowledge requiring bodily coordination (e.g., laboratory operations, sports) is also hard to master effectively without actual practice (Tan, 2025).

III. 1.2 Lack of Bodily Participation in Knowledge Feedback

Knowledge feedback is crucial for cognitive construction (Ye, 2019). In traditional classrooms, feedback is accompanied by rich bodily interactions: the teacher adjusts the pace by observing students' expressions and postures; students convey understanding through gestures and eye contact during discussions (Liu & Tan, 2022). In contrast, AI-led assessment relies on data-driven, standardized answers; it cannot capture bodily participation in the learning process nor provide immediate, situated feedback based on bodily interaction (Luo et al., 2025). This limitation stems from an overemphasis on measurability – the tacit feedback conveyed by the body is difficult to quantify. As a result, teaching feedback focuses only on the correctness of outcomes, neglecting processual evaluation of bodily participation; students lack experiences of bodily trial and error and thus struggle to develop intuitive reflection, hindering the generation of practical wisdom; knowledge construction loses an important calibration basis, and truly personalized learning becomes difficult to achieve (Yuan & Song, 2025).

III. 2. The Subject Level: Obscuring of Bodily Experience in Teacher and Student Roles

III. 2.1 Blurring of the Teacher's Role

The body is the primary medium of teaching. The expression, formation, and internalization of a teacher's role are all related to the body: teachers need to transmit knowledge through physical embodiment, and their professional identity is constructed and confirmed through bodily experience (Liu & Tan, 2022). The inappropriate application of AI is challenging this foundation. The notion that "transmitting fixed knowledge can be done by machines" dissolves the teacher's role authority; AI can monitor classrooms, evaluate learning, and handle

administrative duties, pushing teachers from leaders to facilitators; AI's powerful data processing capability can even match or exceed the teacher's knowledge and experience, undermining their professional status (Yang et al., 2025). For example, some intelligent lesson-planning systems can automatically generate teaching plans; if the teacher merely acts as a "plan executor," their embodied abilities — such as teaching style, bodily demonstration, and improvisation — gradually weaken.

III. 2.2 Weakening of the Student's Subjective Position

The weakening of the student's subjective position manifests as technological objectification, disciplining, and one-dimensionality. Human subjectivity is generated by activity, and the body is the carrier of activity (Luo et al., 2023). AI intervention may lead to the loss of student subjectivity. Technology tends to "objectify" people in education. At the explicit level, the cyborg body of human-machine integration instrumentalizes the living flesh; at the implicit level, AI solves most knowledge-based problems, causing students to rely on technology and lose the capacity for "deep understanding," with thinking confined to the scope delineated by technology and imagination narrowed (Jiao, 2020). Excessive technology penetration may also lead schools to neglect students' individual development, overlooking humanistic dimensions such as emotional needs and value formation.

III. 3 The Environmental Level: Disembodiment of Educational Interactions Mediated by Technology

III. 3.1 Emotional Alienation Between Teacher and Student Due to Technological Barriers

Embodied cognition theory holds that teacher-student emotion depends on co-present, living interaction – an embodied, mind-body integrated, holistic experience generated in real situations (Chen, 2025). However, the penetration of AI is profoundly changing teacher-student interaction (Zou & Zhu, 2024): digital technology transforms the emotional interaction from "human-human" to "human-technology," reducing interaction quality. Traditional face-to-face communication enables deep understanding and intimate relationships (Wei et al., 2024); after AI intervention, teacher-student communication becomes confined to the technical level, and the education process – originally rich in intellectual exchanges – is simplified into fixed procedures. The consequences are a loss of bodily perception and emotional resonance, a degradation of deep thinking and empathy, and the risk that students may fall into machine-like thinking, leading to a loss of humanity.

III. 3.2 Weakening of Peer Collaboration in Virtual Interaction

Bodily interaction among students is a dynamic process based on bodily subjects in real situations (Jiao, 2020). Compared with teacher-student interaction, peer interaction unfolds in a more egalitarian relationship, allowing students to cooperate and express themselves in a relaxed, safe environment (Wei et al., 2024). However, technologically dominated virtual interaction is weakening this collaborative awareness and ability. Take online group work as an example: Group leaders assign tasks through the network, and members work independently, making it difficult to form close coordination and losing the co-construction of the overall goal (Shi & Zhang, 2025). Without the assistance of face-to-face body language and facial expressions, communication is less timely and effective, leading to misunderstandings (Ye, 2023). Information transmission delays and unstable internet

connections further exacerbate communication difficulties. In anonymous or relatively lax online environments, some students have a weak sense of responsibility toward collaborative tasks, exhibiting procrastination and perfunctory behavior, which affects group motivation and learning progress.

These dilemmas are not accidental; their deep-seated causes are analyzed below from three aspects: the conflict between technical rationality and educational logic, the technological uncapturability of tacit bodily experience, and the dissolution of embodied relationships in virtual environments.

IV. Causes of the Dilemmas of Bodily Experience in Teaching in the AI Era

IV.1 The Four-Dimensional Conflict Between "Disembodied" Technical Rationality and "Embodied" Educational Logic

The conflict between technical rationality and educational logic is a key trigger of the dilemmas of bodily experience (Wang, 2026). AI reshapes education into a highly rationalized, data-driven systems engineering, pursuing certainty, optimization, and manageability of the educational process through quantification, calculation, and control – a "disembodied" logic (Li, 2025). In contrast, the essence of education is to cultivate whole persons, relying on emotional contagion through bodily co-presence, teaching by example, and situated experience (Liu & Tang, 2025) – an "embodied" logic. When AI strongly intervenes in education, this conflict unfolds along four dimensions.In terms of educational purpose, technical rationality breaks down goals into quantifiable indicators, treating the student's body as a "qualified product" to meet social demands, while neglecting the awakening of subjective agency, individuality, creativity, and the spiritual world (Dang & Wang, 2025). This is the deep root of the "weakening of students' subjective position" – when students are molded as "products," their living bodily experience is naturally obscured.In terms of educational process, data-driven technical rationality controls the learning flow through behavioral data, avoiding inefficient steps, thereby suppressing bodily generative learning. Educational logic respects the different growth cycles of individuals, emphasizing trial-and-error, reflection, and insight – these unpredictable bodily experiences are precisely what technical rationality rejects (Li & Chen, 2020). This explains why "detachment of bodily experience in knowledge transmission" and "lack of bodily participation in knowledge feedback" occur simultaneously: technical rationality does not allow students to "waste time" on trial-and-error and bodily experience, compressing the knowledge generation process into linear input.In terms of educational relationship, technological mediation dissolves the sense of bodily co-presence: teacher-student interaction is intercepted by technology, and bodily emotional communication is replaced by data (Wei et al., 2024). Educational logic, however, relies on face-to-face trust and care between teachers and students. This is the common root of "emotional alienation between teacher and student" and "weakening of peer collaboration in virtual interaction" – when the sense of bodily co-presence is replaced by technological mediation, emotional connections between people are naturally weakened.In terms of educational evaluation, technical rationality defines educational success or failure through quantitative indicators such as scores and rankings, obscuring the expressive value of the body (Wang, 2020). Educational logic values the inner transformation in the growth process. This directly leads to the "lack of bodily participation in knowledge feedback": technical evaluation can

only capture quantifiable outcomes, failing to see students' bodily participation, emotional fluctuations, and intuitive reflection during the learning process, thus reducing feedback to mere correctness judgments rather than a calibration of the whole learning process.

IV.2 The Uncapturability of Tacit Bodily Experience by Technology

Tacit bodily experience can be understood from the perspectives of tacit knowledge and embodied cognition theory (Chen, 2026). Polanyi pointed out that people always have some knowledge that cannot be expressed in words – "tacit knowledge" or "implicit knowledge." He used the iceberg metaphor: the portion above the water is explicit knowledge, the huge base below the water is tacit knowledge, and most tacit knowledge originates from the human body (Chen & Zhou, 2026) Tacit bodily experience is mainly manifested in sensations, actions, and reactions, existing in the form of non-linguistic abilities, characterized by non-representationality, situational dependence, and dynamic generativity. It is not statically stored in the body but is continuously generated and changed through real-time interaction between the body and the environment (Su & Ye, 2025). In education, this experience manifests as perceptual experience, individual innovation, and inquiry ability, which are important components of students' core competencies. For example, a teacher adjusts the classroom rhythm through subtle gestures, intonation changes, and eye contact – these bodily experiences cannot be recognized or encoded by AI. However, technology cannot capture such tacit experience. The essence of modern technology is "enframing" – it positions everything as "standing-reserve," converting it into calculable resources, but it cannot reach the perceptible, rich, incalculable side behind the body (Qian & Gan, 2026). This explains why in AI-dominant teaching, knowledge feedback remains at the level of right/wrong outcomes, and skill-based knowledge (e.g., laboratory operations, sports movements) is difficult to convey effectively through virtual teaching.

IV.3 The Dissolution of Embodied Relationships in Virtual Teaching Environments

Virtual education environments reshape the embodied relationships in the educational field (Wang, 2020). When educational activities depend on digital interfaces and virtual spaces, technological mediation has two major effects. First, the digital interface weakens embodied cognition (Su & Ye, 2025). Embodied cognition emphasizes the role of body-environment interaction in cognition; concept formation is closely linked to the body's spatial experience, motor perception, and emotional experience. However, current AI education technologies, in order to improve transmission efficiency, filter and simplify the rich, continuous bodily perception, compressing it into discrete knowledge dominated by visual information. As a result, human cognition loses its rich connection with the body and the lifeworld, losing depth and warmth. Second, virtual space restricts embodied interaction (Wang et al., 2025). Traditional embodied education is based on bodily co-presence in physical space, whereas virtual space is non-physical. Its limitations are manifested in three aspects (Yuan & Li, 2025):

Reduction of interaction modes: From multidimensional embodied interaction to unidimensional symbolic transmission.

Spatiotemporal dislocation: In time, network delays interrupt real-time feedback in the classroom, disrupting interaction fluency; in space, remote teaching dissolves the physical co-present space, transforming

close interactions into communication through screens.

Loss of artistic charisma: For example, when a craft is made by hand, the apprentice forms muscle memory by observing the master's hand movements; virtual teaching videos cannot convey the subtle changes in the pressure of the palm against the clay.

These limitations of virtual space are precisely the technological roots of the emotional alienation between teacher and student and the weakening of peer collaboration discussed earlier.

V. Pathways for Returning Bodily Experience to Teaching in the AI Era

V.1 Responding to the Conflict in "Educational Purpose": From "Standardized Output" to "Awakening of Subjectivity"

Technical rationality breaks down educational goals into quantifiable indicators, treating students as "qualified products" to meet social demands. To resolve this conflict, we must let technology serve "human development in all its dimensions" – not the reverse. In instructional design, teachers should distinguish between "quantifiable knowledge and skills" and "non-quantifiable subjective competencies." The former can be assisted by AI; the latter – such as curiosity, creativity, value judgment, and emotional capacity – must be cultivated through face-to-face bodily interaction and authentic situational experiences. For example, AI can correct grammatical errors in compositions, but the depth of thought and emotional expression in essays must be assessed by the teacher in person.

V.2 Responding to the Conflict in "Educational Process": From "Data Control" to "Trial and Error & Insight"

Technical rationality controls the learning process through behavioral data, avoiding inefficient steps, thereby suppressing unpredictable bodily experiences. To resolve this conflict, we need to reserve space for "trial-and-error, reflection, and insight" within technology-dominant learning. Concretely, teachers can set "AI-free periods" – recommended for implementation from upper elementary grades and above, with 1-2 hours daily of learning tasks that forbid AI, requiring students to think independently, work with their hands, and learn through trial and error. For example, in a math class, AI may show solution steps, but students must calculate by themselves; in group discussions, AI may only be used for information retrieval, while the discussion itself must be face-to-face (Liu & Tan, 2022). Ye emphasized that bodily trial-and-error experience is the basis for generating practical wisdom, an experience that cannot be replaced by technology (Ye, 2019).

V.3 Responding to the Conflict in "Educational Relationship": From "Technological Interception" to "Bodily Co-Presence"

Technological mediation transforms teacher-student interaction from "human-human" to "human-technology," dissolving the sense of bodily co-presence (Wang, 2026). To resolve this conflict, we need to clearly demarcate the boundaries of human-machine division, ensuring that emotional communication and bodily demonstration are not replaced by technology. Schools should formulate an "AI usage checklist" that clearly specifies which links allow AI intervention and which are prohibited. For example, AI can be used for knowledge retrieval, homework grading, and learning data analysis; but links involving emotional communication,

value guidance, and bodily demonstration – such as class meetings, psychological counseling, laboratory operations, and physical training – must be completed by the teacher in person. Yang et al. point out that clearly defining the boundaries between humans and technology is a prerequisite for avoiding subject alienation(Yang et al., 2025).

V.4 Responding to the Conflict in "Educational Evaluation": From "Quantitative Indicators" to "Inner Transformation"

The evaluation system dominated by technical rationality defines educational success or failure through scores and rankings, failing to capture the value of bodily participation, emotional interaction, and inner transformation (Chen & Chen, 2026). To resolve this conflict, we need to establish a humanistic evaluation system that can capture "bodily experience." When assessing the effects of technology application, schools should not only examine quantitative indicators such as "efficiency improvement" and "score increase," but also incorporate humanistic indicators such as "student bodily participation," "frequency of teacher-student interaction," and "quality of emotional connection" (Zhao et al., 2026). For example, classroom observations can record students' bodily participation (e.g., raising hands, speaking, performing experiments); teacher-student interviews can assess the quality of emotional interaction. Huang points out that only by including bodily participation in the evaluation system can teaching truly be guided toward embodiment (Huang, 2026).

V.5 Responding to the Loss of Tacit Experience: From "Technological Substitution" to "Bodily Awakening"

In response to the dilemma that tacit bodily experience cannot be captured by technology, education needs to design activities specifically aimed at awakening bodily experience (Yang, 2026). It is suggested to introduce a "body diary" – students record their bodily feelings during learning, for example, "When I solved this problem, my palms were sweating," "During the group discussion, I unconsciously leaned forward" – to help them become aware of the connection between body and cognition. At the same time, sufficient offline hands-on time should be preserved in skill-oriented courses (e.g., laboratory work, physical education, arts) to avoid completely replacing real operations with virtual simulations. Teachers should receive training in "embodied pedagogy," learning how to convey tacit knowledge through body language, spatial positioning, and rhythmic variation (Ren et al., 2026).

VI. Conclusion and Outlook

The integration of artificial intelligence and education, while bringing opportunities, has also placed bodily experience in teaching in a difficult position (Zou & Zhu, 2024). Embodied cognition theory reveals the critical role of the body in the cognitive process (Su & Ye, 2025). The roots of the dilemmas lie in the conflict between "disembodied" technical rationality and "embodied" educational logic, the technological uncapturability of tacit bodily experience, and the dissolution of embodied relationships in virtual teaching environments (Li & Chen, 2020).

To resolve these dilemmas, we need to precisely respond to the four-dimensional conflicts between technical rationality and educational logic (purpose, process, relationship, evaluation) (Liu & Tang, 2025): in

educational purpose, shift from "standardized output" to "awakening of subjectivity"; in educational process, shift from "data control" to "trial and error & insight"; in educational relationship, shift from "technological interception" to "bodily co-presence"; in educational evaluation, shift from "quantitative indicators" to "inner transformation"; additionally, design bodily awakening activities to compensate for the loss of tacit experience (Chen et al., 2024).

In the future, as artificial intelligence is more deeply applied, education must continuously attend to the issue of bodily experience, ensuring that technology serves the essence of education rather than deviating from it. Research limitations: This paper is a theoretical analysis lacking empirical data support. Future research could conduct embodied-cognition-oriented AI education experiments, comparing learning outcomes between body-present and body-absent conditions; it could also develop observational tools to assess bodily participation, providing a measurement basis for embodied education. Interdisciplinary research – integrating cognitive science, education, psychology, neuroscience, etc. – will provide more comprehensive theoretical support.

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