

LEARNING TO CARE BY DOING:
EMBODIMENT, TINKERING AND INCLUSIVE PEDAGOGICAL DESIGN
IN MEDICAL EDUCATION

IMPARARE A PRENDERSI CURA FACENDO:
EMBODIMENT, TINKERING E PROGETTAZIONE PEDAGOGICA INCLUSIVA
NELLA FORMAZIONE MEDICA



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ABSTRACT

English

This paper addresses medical education through the paradigm of embodiment, interpreting care as an embodied educational practice. By integrating tinkering, corporeality and Universal Design for Learning, the article proposes an inclusive pedagogical design aimed at fostering integrated competences, reflexivity and professional agency. Tinkering-based learning environments are analysed as experiential educational devices capable of supporting situated learning processes and a form of medical education that is authentically person-centred.

Italiano

Il contributo affronta la formazione medica a partire dal paradigma dell'embodiment, interpretando la cura come pratica educativa incarnata. Attraverso il dialogo tra tinkering, corporeità e Universal Design for Learning, l'articolo propone una progettazione pedagogica inclusiva orientata allo sviluppo di competenze integrate, riflessività e agency professionale. Gli ambienti tinkerabili sono analizzati come dispositivi formativi esperienziali capaci di sostenere apprendimenti situati e una medical education autenticamente centrata sulla persona.

KEYWORDS

Medical pedagogy; Embodiment; Tinkering; Pedagogy of care; Inclusive pedagogical design.
Pedagogia medica; Embodiment; Tinkering; Pedagogia della cura; Progettazione pedagogica inclusiva.

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Introduction

In recent years, university education in the medical and healthcare fields has undergone a profound epistemological and pedagogical reconfiguration. The increasing complexity of health and care needs, together with contemporary social, cultural and demographic transformations, has highlighted the limitations of educational models focused exclusively on the transmission of technical and scientific knowledge. Although indispensable, such competences are no longer sufficient to support a form of medical professionalism capable of addressing the relational, ethical and experiential dimensions of care (Engel, 1977; Frenk et al., 2010). Within this framework, medical pedagogy emerges as a critical field for rethinking university education from a genuinely person-centred perspective.

The centrality of care represents a key theoretical node in this reconfiguration. Care cannot be reduced to a clinical act alone, but must be understood as an educational relationship and a practice of responsibility that involves the whole subjectivity of the professional. It engages cognitive, emotional and bodily dimensions and cannot be learned solely through protocols or abstract knowledge. Rather, care is progressively constructed through situated, reflective and relational experiences that contribute to the development of professional identity. Pedagogical research has emphasised the need to overcome traditional dichotomies between theory and practice, rationality and experience, mind and body in educational processes oriented toward care (Mortari, 2013; Cambi, 2010).

Within this perspective, the paradigm of embodiment offers a particularly fruitful theoretical lens for reinterpreting professional learning in medical education. By challenging dualistic conceptions of knowledge, embodiment recognises the lived body as a primary site of experience, understanding and relationship (Merleau-Ponty, 1945; Varela et al., 1991). Learning to care thus entails the development of an embodied sensitivity that integrates perception, action, emotion and reflection, all of which are central to clinical and relational competences. Consequently, medical education cannot overlook pedagogical practices that value bodily experience as a constitutive dimension of professional knowledge.

In this theoretical horizon, tinkering can be interpreted as a meaningful pedagogical device. As a learning practice grounded in exploration, experimentation and productive error, tinkering promotes learning by doing and makes cognitive processes visible, thereby fostering reflexivity (Resnick & Rosenbaum, 2013). Tinkering-based learning environments support situated and collaborative learning, in which the body, materials and action function as fundamental mediators of knowledge (Lave & Wenger, 1991). When applied to medical education, tinkering

contributes to the development of essential competences for care, such as attentiveness, listening, tolerance of uncertainty and adaptive capacity in complex contexts.

For these practices to fully express their educational potential, they must be embedded within an inclusive pedagogical design. In this regard, Universal Design for Learning provides a theoretical and operational framework for designing flexible and accessible learning environments that respond to learner variability and to different ways of learning, acting and participating (CAST, 2018; Meyer et al., 2014). The integration of embodiment, tinkering and UDL enables the reimagining of medical education as a formative process that goes beyond knowledge transmission, fostering integrated competences, reflexivity and professional agency in line with a person-centred approach to care (van der Vleuten et al., 2015). On these grounds, this paper aims to explore the potential of the embodied paradigm and tinkering as pedagogical devices for inclusive design in medical education. The contribution offers a theoretical and methodological reflection that brings into dialogue the pedagogy of care, embodied learning and educational innovation, outlining perspectives for a form of medical education oriented toward responsibility, relationality and human dignity.

1. Person-centred education, educational relationships and professional responsibility

Within the context of university education in the medical and healthcare fields, the pedagogy of care plays a strategic role in redefining the aims, contents and educational devices of medical education. Care cannot be interpreted merely as a set of technical acts aimed at diagnosis and treatment; rather, it emerges as a complex practice that involves the person as a whole. It encompasses cognitive, ethical, affective and relational dimensions, making the formation of healthcare professionals a profoundly educational process, not limited to technical specialisation.

From this perspective, care becomes a pedagogical category capable of orienting formative processes by placing the relationship between the learner and the person being cared for at the centre. As Mortari (2013) argues, care possesses an intrinsic formative value insofar as it calls for attentiveness, responsibility and awareness, functioning as a reflective practice that transforms those who engage in it. Applied to medical education, this approach enables a move beyond training-oriented models of learning towards pathways that support the development of reflective and responsible professional stances.

Elsa Maria Bruni's contribution is particularly significant in grounding a pedagogical understanding of care as a structural dimension of educational processes. Her work conceptualises care as a formative principle permeating educational experience as a whole, placing the person at the centre in their affective, relational and desire-oriented dimensions (Bruni, 2016). From this standpoint, education cannot be reduced to the transmission of knowledge; rather, it becomes a space for meaning-making in which learners are recognised as active agents in their personal and professional development.

This perspective is further strengthened by reflections on the epistemological identity of pedagogy as a science of the human. Bruni highlights how contemporary pedagogy is called to redefine its epistemological foundations by assuming care as an orienting principle capable of integrating rationality, experience and the embodied dimension of the subject (Bruni, 2019). In medical education, this entails recognising that professional training concerns not only the acquisition of clinical competences but also the construction of a professional ethos grounded in responsibility toward others.

The dialogue between the pedagogy of care and medical education is particularly meaningful when situated within the broader debate on overcoming the traditional biomedical paradigm. Since the introduction of the biopsychosocial model, scholarly literature has emphasised the need to integrate biological dimensions of illness with psychological and social ones, acknowledging the person as an active subject in care processes (Engel, 1977). In this sense, medical education is increasingly called upon to foster competences that extend beyond technical mastery to include listening, understanding and relational capacities.

These considerations are further supported by contributions that stress the urgency of transforming medical curricula in response to contemporary healthcare challenges. Frenk et al. (2010) argue that the education of health professionals must focus on developing integrated competences capable of sustaining responsible and context-sensitive care practices. Within this framework, the pedagogy of care provides a crucial interpretative lens for rethinking medical education as a person-centred educational process in which knowing, doing and being are deeply interconnected.

2. The lived body as an epistemic device in medical education

The embodiment paradigm currently represents one of the most robust theoretical frameworks for rethinking professional learning processes, particularly in educational contexts characterised by high relational and decision-making density, such as medical education. By overcoming the traditional mind-body dualism,

embodiment recognises the lived body as a primary site of experience, meaning-making and knowledge construction. From this perspective, knowledge is not conceived as an abstract and disembodied entity, but as a situated process emerging from the dynamic interaction between subject, environment and action (Merleau-Ponty, 1945).

Phenomenology has provided a crucial contribution to this reconceptualisation by demonstrating that perception is not a purely cognitive act, but an embodied experience that structures our being-in-the-world. Merleau-Ponty emphasised that the body is not an object among objects, but the medium through which the subject engages with reality and attributes meaning to lived experience. This view is particularly relevant for medical education, where learning unfolds through practices that constantly involve bodily perception, gesture and interpersonal interaction.

Building on this phenomenological foundation, cognitive sciences have further developed the embodied paradigm by highlighting the enactive and situated nature of cognition. Varela, Thompson and Rosch (1991) conceptualised cognition as an emergent process arising from the subject's embodied action in the world, thus moving beyond computational and representational models of the mind. In educational terms, this implies recognising learning as a process grounded in experience, action and reflective engagement, rather than mere information acquisition.

In the field of professional education, these perspectives have been integrated into situated learning theories and models of reflective practice. Professional learning is thus understood as a process that develops within real or simulated contexts through active participation in socially shared practices (Lave & Wenger, 1991). In medical education, this approach allows clinical experience to be valued not merely as an application phase, but as a privileged space for professional knowledge construction, in which the learner's body is continuously involved in decision-making, interpretation and relational engagement.

The relevance of embodiment in medical education has also been highlighted by research emphasising the role of bodily experience in the development of clinical and empathic competences. Gallagher (2005) demonstrated that understanding others is grounded in bodily and pre-reflective processes that precede explicit cognitive elaboration, while Shapiro (2011) emphasised the importance of educational practices capable of integrating bodily, emotional and narrative dimensions in healthcare training. From this perspective, empathy and listening are not simply communication skills, but embodied competences cultivated through experience and guided reflection.

Adopting embodiment as a guiding paradigm for medical education therefore entails a profound rethinking of pedagogical devices and learning environments. It requires acknowledging that the learner's body is not merely an operational tool, but an epistemic device through which forms of attention, presence and relational awareness are learned. In this sense, embodiment provides a foundational theoretical framework for reimagining medical education as an integral educational process in which knowing, doing and feeling are inseparably intertwined.

From this perspective, *clinical reasoning* can also be understood as an embodied and situated process that cannot be reduced to the application of decision-making algorithms. Rather, it develops through the interaction between bodily perception, clinical experience and reflection on action. Clinical judgment thus emerges as an embodied cognitive practice, sensitive to context and to the care relationship, rather than as the mere application of abstract knowledge (Durning et al., 2012; Gruppen, 2017).

3. Learning by doing through experience, productive error and reflexivity in medical education

Within an embodiment framework, tinkering can be understood as an embodied educational practice that connects learning, action and meaning-making. As an activity grounded in exploration, material engagement and productive error, tinkering makes thinking processes visible as they unfold and supports forms of situated reflexivity that are crucial for professional education (Resnick & Rosenbaum, 2013). Its relevance for medical education lies precisely in its capacity to cultivate competences that are built in and through action: attentiveness, presence, tolerance of uncertainty, adaptive reasoning and the ability to reframe problems when data do not immediately align.

Read through this lens, tinkering appears particularly aligned with the development of *clinical reasoning*, as it enables forms of reasoning based on provisional hypotheses, iterative adjustments and learning from error. The possibility of "thinking through making" renders decision-making processes visible and fosters metacognitive reflection on how clinical judgment is constructed, supporting key competences for dealing with the uncertainty inherent in care contexts (Norman, 2005).

This perspective is increasingly supported by the emergence of medical makerspaces and making initiatives within healthcare education. Some contributions explicitly propose medical maker curricula that integrate digital fabrication and hands-on prototyping as educational devices for fostering empathy,

interprofessional collaboration and needs-driven problem solving (Albala et al., 2018). Similarly, recent work on the design of 3D printing curricula in medical schools highlights hands-on learning and lab-based pedagogies as levers for conceptual understanding, knowledge integration and transferable skill development (Heiser, 2025). These trajectories suggest that tinkering is not merely “creative doing”, but a pedagogical device enabling iterative, situated learning oriented toward responsibility.

Beyond educational design, the notion of tinkering is also used in recent scholarship as a lens to analyse care practices themselves, emphasising their adaptive and non-linear nature. Qualitative studies of clinical encounters describe care as a process of continuous adjustments, micro-decisions and responsible experimentation, where what matters is not the mechanical application of protocols but making care work in concrete contexts with specific persons (Skovgaard, 2024). Along similar lines, research on clinical expertise highlights how “tinkering” and collaborative adjustment processes contribute to learning and the development of distributed forms of expertise among clinicians (Gibson et al., 2023). These contributions strengthen the argument that tinkering can serve as a conceptual and methodological bridge between education and professional practice, making medical education more consistent with the actual nature of care.

Adopting tinkering as an embodied pedagogical practice therefore entails designing learning environments in which experience is not relegated to a post-theory “application” phase, but becomes a generative space for conceptualisation, reflection and professional identity formation. From this perspective, tinkering functions as a learning device integrating body, materials, the narrative of error and reflexivity, offering a fertile ground for cultivating both clinical and relational competences in ways aligned with person-centred approaches and the complexity of contemporary healthcare contexts.

In recent years, *medical makerspaces* have gained increasing attention within international scholarship on health professions education. These spaces are described as hybrid learning environments in which making, rapid prototyping and tinkering practices are embedded in medical curricula to support experiential and interprofessional learning. Early studies show that the introduction of makerspaces in medical education fosters the development of key transversal competences, including collaboration, empathy toward patients’ needs and the ability to design context-sensitive solutions (Bar-El et al., 2020; Marshall & Harron, 2018).

Marshall and Harron (2018) highlight how making activities in healthcare contexts enable medical students to engage early with authentic problems, promoting user-centred learning and social responsibility. Similarly, Bar-El et al. (2020)

conceptualise the makerspace as a pedagogical device capable of bridging the gap between theory and clinical practice, fostering a culture of responsible innovation grounded in attention to real care needs.

Further contributions emphasise that making in medical education supports reflective and metacognitive competences, allowing students to make explicit the decision-making processes underlying design and adaptation practices (George et al., 2021). From this perspective, tinkering extends beyond technical skill development and emerges as an embodied practice that nurtures learning from error, problem reframing and the gradual construction of professional expertise.

These experiences confirm that medical makerspaces should not be understood merely as sites of technological innovation, but as embodied pedagogical environments in which body, materials and action function as central mediators of learning. When situated within such contexts, tinkering contributes to the formation of professionals capable of inhabiting uncertainty, collaborating across disciplines and caring for persons through design practices attuned to the complexity of real-life healthcare settings.

4. Universal Design for Learning, flexible learning environments and educational responsibility

Contemporary medical education unfolds within learning contexts characterised by high cognitive, relational and emotional complexity, increasingly challenging standardised and uniform instructional design models. Within this framework, inclusive pedagogical design should not be understood as a set of compensatory measures targeting specific learner groups, but rather as a structural principle recognising learner variability as an inherent condition of learning processes. Universal Design for Learning (UDL) offers a theoretical and operational framework aimed at anticipating such variability and guiding the flexible and accessible design of learning environments (CAST, 2018; Meyer et al., 2014).

In medical education, adopting UDL enables curricula to be reconceptualised as complex educational systems in which disciplinary content, learning practices and assessment processes are coherently integrated. Providing multiple means of representation, action and expression, as well as engagement, creates educational conditions that support meaningful participation and foster the development of deep and transferable professional competences. This perspective aligns with international scholarship calling for the transformation of health professions education in response to the complexity of contemporary care systems (Frenk et al., 2010).

The integration of UDL with embodiment and tinkering further strengthens this design perspective. Embodied and hands-on practices developed within tinkerable environments and makerspaces require pedagogical devices capable of supporting exploration, productive error and reflexivity without reverting to rigidly prescribed sequences. UDL provides a conceptual structure that legitimises such practices as central components of medical education, valuing situated learning and bodily experience as constitutive dimensions of professional knowledge (Resnick & Rosenbaum, 2013; Lave & Wenger, 1991). Within this framework, simulations, making laboratories and design-based activities fulfil an epistemic function, contributing to the development of integrated clinical and relational competences. Assessment represents another key dimension of inclusive pedagogical design. In line with UDL principles, assessment should not be confined to summative certification, but should function as an ongoing formative process supporting learning and professional development. Programmatic assessment models highlight how the systematic collection of multiple data points over time, combined with structured feedback, supports the development of complex and integrated professional competences (van der Vleuten et al., 2015). In medical education, such approaches resonate strongly with care-oriented perspectives, emphasising learning trajectories rather than isolated performances.

Finally, adopting UDL as a guiding principle for pedagogical design in medical education entails a redefinition of the educator's role. Educators are called to act as designers of learning environments and facilitators of reflective processes, capable of observing learner variability and dynamically adapting educational proposals. This shift requires specific pedagogical competences and an institutional culture committed to inclusion and educational quality, consistent with an understanding of medical education as an integral, person-centred educational process (Mortari, 2013; Bruni, 2019).

5. Curricula, educational devices and professional development

The integration of the pedagogy of care, the embodiment paradigm, tinkering practices and Universal Design for Learning generates significant pedagogical implications for medical education at curricular, organisational and institutional levels. Adopting these theoretical frameworks invites a reconceptualisation of curricula not as linear sequences of disciplinary content, but as **learning ecologies** in which knowledge, practices and experiences are intentionally designed and interconnected. From this perspective, professional learning is supported through

educational devices that value embodied experience, reflexivity and active student participation.

At the level of educational devices, this approach entails the systematic integration of laboratories, simulations, makerspaces and design-based activities within medical education programmes. When designed according to UDL principles, such environments provide multiple means of accessing content, acting and engaging, thereby supporting authentic and situated learning processes (CAST, 2018; Meyer et al., 2014). In particular, tinkering and making practices enable the development of competences that are crucial for care, including uncertainty management, collaborative problem solving and adaptive capacity in complex contexts, in line with international calls for transforming health professions education (Frenk et al., 2010).

A second key area concerns faculty development and the pedagogical culture of academic institutions. The adoption of embodied and inclusive approaches requires a redefinition of the educator's role, shifting toward that of a learning environment designer and facilitator of reflective processes. In this regard, faculty development plays a strategic role in fostering pedagogical competences capable of integrating disciplinary expertise with relational and evaluative dimensions. Inclusive design and flexible educational practices also demand coherence between teaching and assessment, encouraging formative and developmental assessment models such as programmatic assessment (van der Vleuten et al., 2015).

From a research perspective, the proposed framework opens up several promising lines of inquiry. Qualitative and mixed-methods studies could explore how students and educators experience embodied and tinkerable learning environments, focusing on learning processes, meaning-making and professional identity development. At the same time, design-based research approaches may contribute to evaluating the effectiveness of inclusive educational environments in medical education, examining the relationships between pedagogical design, learning devices and educational outcomes. In this sense, the dialogue between pedagogy and medical education represents a fertile space for developing educational models capable of addressing contemporary care challenges in a responsible and sustainable manner.

In this direction, the integration of embodiment, tinkering and inclusive pedagogical design offers a promising framework for strengthening *clinical reasoning* in medical education. Flexible and tinkerable learning environments can support the development of complex decision-making abilities by fostering reflection on action, peer dialogue and the progressive construction of clinical judgment in authentic and simulated learning situations.

Conclusions

This paper has offered a pedagogical reflection on medical education grounded in the assumption that learning to care cannot be reduced to the acquisition of technical and scientific competences alone. Rather, it requires a broader formative process capable of integrating cognitive, bodily, relational and ethical dimensions. From this perspective, care has been conceptualised as an embodied educational practice that involves the professional's whole subjectivity and is constructed through situated, reflective and relational experiences (Mortari, 2013; Bruni, 2016). The embodiment paradigm has provided a robust theoretical framework for rethinking professional learning in medical education, challenging dualistic conceptions of knowledge and recognising the lived body as a central epistemic device in learning processes (Merleau-Ponty, 1945; Varela et al., 1991). Within this framework, learning by doing acquires specific educational value, as it enables the integration of perception, action and reflection in the development of clinical and relational competences.

In this horizon, tinkering has been analysed as an embodied educational practice capable of making thinking processes visible, valuing error as a formative resource and supporting situated learning. Experiences of tinkerable environments and makerspaces in medical education demonstrate how such practices can function as powerful formative devices, fostering competences that are crucial for care, including uncertainty management, collaborative problem solving and responsiveness to patients' needs (Resnick & Rosenbaum, 2013; Bar-El et al., 2020; Barra, 2025).

The integration of Universal Design for Learning has allowed these practices to be framed within an inclusive pedagogical design oriented toward anticipating learner variability and providing multiple means of access, action and expression (CAST, 2018; Meyer et al., 2014). From this perspective, inclusion is not conceived as a marginal accommodation, but as a criterion of educational quality in curriculum design and professional training. Coherence between teaching, learning environments and assessment, particularly through programmatic assessment models, further strengthens a vision of medical education oriented toward progressive and reflective competence development (van der Vleuten et al., 2015). Taken together, the theoretical frameworks discussed outline a view of medical education as a learning ecology in which body, experience, design and relationship contribute to the construction of a responsible and person-centred professionalism. Future research directions include, on the one hand, the empirical

investigation of embodied and tinkerable learning environments in medical education contexts and, on the other, the exploration of how such experiences support professional identity formation and care-oriented dispositions. In this sense, the dialogue between pedagogy and medical education emerges not merely as desirable, but as necessary for addressing the challenges of contemporary care in a critical and sustainable way.

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