Journal of Inclusive Methodology and Technology in Learning and Teaching
ISSN 2785-5104
Anno 6 n.1 (2026)

EDIZIONI UNIVERSITARIE ROMANE
editoria scientifica dal 1952

Pedagogical challenges in the techno-scientific intertwining: towards an embodied reading of cognitive experience

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Abstract: Interpreting reality as the sum of isolated elements is an attitude that has emerged throughout the history of Western thought, which, in its search for absolute truths, has adopted reductionist epistemological canons. The ambition established by modern science to control and predict events is reflected in a transmissive educational model, based on the unilateral transfer of knowledge. This work aims to consider the contribution of complexity sciences, which, in dialogue with lines of inquiry such as Embodied cognitive science, allow for a systemic view: the individual is *body-mind-environment* in relation, and knowledge emerges in the interconnections and unprecedented exchanges of this intersubjective network. Technologies, and in particular embedded ones such as Social Robots, fit into this intertwining with their presence, giving rise to *mixed ecologies* and helping to transform the cognitive experience. Going beyond the polarity between *technophilia* and *technophobia* becomes essential for a critical pedagogy: risks and possibilities are not defined by the artificial product itself, but by the relationship between it and the context of interactions in which it is immersed. A transdisciplinary reflection aimed at the ethical exploration of the trajectories that lie ahead is necessary to take responsibility for moral growth and sustainable planetary coexistence.

Keywords: Technophilia vs technophobia; Embodied cognitive science; Social Robotics; Educational ecologies; Enactive mind

1. *Homo sapiens-demens* and technology

Addressing the technoscientific question from an educational perspective requires, first and foremost, contextualizing humanity within the horizon of technology. According to Edgar Morin, humans, who originated in a chaotic cosmic history, have the peculiarity of being cerebrally *sapiens-demens*: ambivalent aspects such as rationality, delirium and destructiveness coexist simultaneously within them (2002). The human adventure is the bearer of this constitutive contradiction, developing between creations, innovations, barbarism, devastation, great ideas, and violent drifts. The author highlights the formidable potential for technical development through which *homo sapiens*, a species not particularly advantaged from an evolutionary point of view, has imposed its dominance over the entire planet. However, focusing exclusively on its rational abilities would give a partial overview; in fact, human identity, Morin reminds us, also encompasses madness, magic, and myth: these are not left behind by scientific progress, but rather are part of it. It is from these roots that it is possible to construct a conscious and critical discourse on our relationship with technology. While increasingly complex innovations have led to apparent control over reality, our biological roots urge us to reflect on the interdependence between ecosystems and spe-

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cies. In light of the intertwining of reason and delirium, humanity has discovered laws, created artifacts, reshaped nature, and now finds itself in a position to rediscover the connections that bind it to Earth's destiny and place limits on the exploitation of resources. The analysis of technology must start from the cognitive assumptions on which scientific discourse is based, since, as Gregory Bateson argues, «epistemological error is all right, […] up to the point at which you create around yourself a universe in which that error becomes immanent in monstrous changes of the universe that you have created and now try to live in» (1972/1987, pp. 490-491).

In order to develop an ethical reflection aimed at sustainable coexistence with technologies, it is necessary to consider them within the entire creative process: from conception to the stages of construction, experimentation, distribution, and use, with the related unpredictable interpretations that arise when they are inserted into a living context. The digital revolution challenges us to reevaluate the paradigms with which Western society conducts scientific inquiry, in which a mechanical and linear view of reality has prevailed for centuries. Since technologies generate unprecedented ecologies, the questions to be asked must go beyond simplistic positions and take a systemic view of interaction with non-human artifacts. Going beyond a reductionist approach allows us to avoid polarizing ourselves on the *technophilia-technophobia* dichotomy. It is not a question of determining whether technologies are 'right or wrong', but of understanding the meanings of the exchange – which is totally new – with humans, investigating values, possibilities, fluctuations, risks (Rivoltella, Rossi, 2019), and remembering that the actor involved, in his journey of discovery, brings with him delirium as well as reason.

2. Technologies and epistemological lenses

The impact of the positivist paradigm on the understanding of events emerges in contemporary scientific research, where knowledge is often defined as an accumulation of information to be analyzed by isolating phenomena. The ideal of *omniscience* (Ceruti, 2014), typical of modern thinking, aims to identify universal laws capable of dissolving the complex into the simple, and of explaining reality in order to make it predictable and controllable. In contrast, the sciences of complexity highlight that abstracting an event from the network of relationships in which it is generated leads to a blind view. From this perspective, there is no single code for reading reality – nor even definitive knowledge – since reality can be described through infinite languages, always local and partial: it is inexhaustible (Damiano, 2009).

Until the 1980s, Cartesian reductionism – which excludes the body and environment from cognitive processes – was reflected in cognitive science in a computationalist model that likened the functioning of the mind to that of a digital computer (Ceruti, Damiano, 2010). Research approaches such as the autopoietic biology of Francisco Varela and Humberto Maturana problematize this view, highlighting the connection between living beings and knowledge. According to the authors, any cognitive experience is rooted in the biological structure of living systems, which explore reality through specific, situated actions; consequently, they cannot be understood separately from the environment with which they interact and the physicality they embody (Maturana, Varela, 1985). Departing from the analogy between cognition and closed computer circuits, the approach of embodied cognitive science emerges, which reintegrates bodies and ecologies into scientific inquiry. In particular, Francisco Varela, Evan Thompson, and Eleanor Rosch propose an enactive ap-

proach, which conceives the mind as a changing set of emerging processes involving the brain, body, physical environment, and social environment (1991/2024). The organism is interpreted in light of its interactions with the world, with which it establishes continuous exchanges, generating mutual transformations and constantly reorganizing itself. The history of each system, the result of a complex co-evolutionary, biological, sensory, and cultural intertwining, then becomes unique, unpredictable, circumstantial, and non-generalizable.

Addressing the issue of knowledge in the field of artificial sciences is essential because, in the creation of technological products, they implement models of cognition that reflect the epistemological dimensions within which they are conceived and developed. These artifacts are not neutral objects: beyond their specific functions, they incorporate networks of values, representations, and symbols that come from a particular cultural, historical, and economic context.

When personal computers became widespread in homes in the late 1970s, Seymour Papert (1980) questioned the educational contribution of a tool that was potentially capable of overcoming barriers to access to knowledge and involving all children in the generation of powerful, heartfelt, personal ideas. The more skeptical schools of thought did not foresee radical changes with regard to the widespread use of computers, while critics feared negative effects linked to increased inequality and alienation. Unlike both, Papert distinguished the possibilities of the object itself from the ways in which society would use it, inviting us to consider it within its context. The mere presence of computers would not have defined anything, since the future would have been shaped by a combination of political decisions, ethical issues, social trends, and epistemological considerations. Papert's analysis challenges us to broaden the framework within which the debate on technology takes place: in order to develop an in-depth and informed line of ideas, artifacts must be investigated as elements that interact within a system of exchanges, modifying cognitive and relational processes.

A particularly significant area in which these issues emerge considerably is Social Robotics. Luisa Damiano and Paul Dumouchel invite us to think of robotic agents as «instruments for research in the ethical domain» (2017, p. 172) and for self-exploration, rather than mere servile machines. According to the authors, robots capable of exchanging social signals with humans can provide an opportunity for learning and moral growth.

3. Social Robots in the Body-Mind-Environment Network

Interpreting robotic agents within social contexts is not a neutral operation, but involves specific cognitive assumptions. Positions oriented towards technological determinism focus on a subordinate view of these spaces, which become «passive objects of the transformative action exercised by new machines»[1] (Damiano, 2020, p. 28). In this case, the underlying reductionist attitude, which believes that reality can be analyzed by fragmenting its parts, considers the technical object as a component that is added, causing unilateral changes. However, from a systemic point of view, the whole is described as something that exceeds the simple sum of its parts and emerges from mutual exchanges; therefore, in the study of technologies, «it is impossible not to

[1] Translation by the author.

take into account the human network in which they are immersed»[2] (Alessandri, 2014, p. 111). Human-robot interactions generate so-called *mixed social ecologies* (Damiano, 2020), in which participants, living and non-living, share a web of connections; there is no passive party that undergoes the action of the other, but a circuit of interdependencies that redefines the relational experience. The dialogue that opens up presents totally new coordinates in the study of cognition and sociality, domains in which these interlocutors challenge us to rethink traditional definitions and broaden our reflection on the human condition.

Unlike virtual technologies designed to 'dematerialize', Social Robots actively occupy spaces, taking up a tangible position with their physicality (Dumouchel, Damiano, 2017). Thanks to their three-dimensional nature, an embedded encounter takes place between robots and living organisms, which are confronted with cognitive models integrated into completely different systems. Social robotics aims to build agents capable of communicating with humans through compatible signals (Damiano, 2020), according to different channels, enriching interaction – it is not, therefore, a question of replacing the human figure. These robots do not have unique and exclusive functions, but ideally should adjust themselves according to heterogeneous social situations, diversifying their actions and coordinating with their interlocutors. For example, Paro[3], a zoomorphic robot resembling a seal, is designed to autonomously seek interaction through a wide range of movements and sounds; it also reacts to touch via sensors and, thanks to its evocative design, lends itself to use in pet therapy with elderly people, creating an opportunity for socialization as it becomes «something that is agreeable to talk about and show an interest in» (Dumouchel, Damiano, 2017, p. 158). Social robots are a very heterogeneous class in terms of form, characteristics, and the spaces in which they are intended to be used – mainly places of interaction (education, entertainment, assistance, etc.). Current research investigates ways in which humans can be facilitated in recognizing robots as interlocutors, a process that ranges from the tendency toward anthropomorphization and engagement triggered by movement (Damiano, Dumouchel, 2018) to the study of physical design and engineering properties, including gazes, appearances, communication channels, gestures, postures, and movements (Lehmann, Murru, 2024).

Thinking about the human-robot relationship in the light of a framework of co-evolutionary exchanges between elements of a system refers to the deeper meaning that is given to the cognitive experience: even the encounter with robotics involves the psychomotor dimension, which is at the basis of the exploration of the world. According to Vittorio Gallese and Ugo Morelli (2024), understanding cognition cannot be separated from the motor brain: movement – which enables the body-mind-environment relationship – is at the heart of any human experience. The enactive model outlined by Varela and his collaborators (a mind that emerges in connections with elements of reality according to mutual transformations) allows us to consider Social Robots as potential systems capable of coordinating socially with humans, albeit under certain conditions and in a different way than living organisms (Damiano, 2020).

[2] Translation by the author.

[3] http://www.parorobots.com/

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As embodiments of scientific theories that are never neutral, these technologies require critical transdisciplinary reflection, capable of not isolating itself in superficial fears or hyper-sectoralized procedures. In a reductionist worldview that separates man from nature, the mind from the body, knowledge from the cognitive process, any creation becomes an external object, detached from the epistemological coordinates within which it was created. There is then a risk of blindly relying on the potential of technology or, at the opposite extreme, rejecting it *a priori*, considering it dangerous and deceptive. With regard to Social Robots, according to Damiano (2021), it is necessary to orient every phase of research towards sustainability criteria, outlining shared guidelines – a *synthetic ethic* – to analyze the moral aspects raised by these new presences; failure to do so would mean delegating the management of the artificial to the market. Extending the theme to the entire debate on technology, it is not a question of condemning or acquitting it definitively, but of contextualizing the product created, the creator, and the process of creation within a network of circular, retroactive, and unpredictable exchanges.

This requires self-critical pedagogical reflection, capable of taking on board a historical, cultural, and scientific context in which the meanings of cognition, sociality, and knowledge are transformed and call for a revision of traditional systems.

4. Educational ecologies

«Educational action is first and foremost existentially situated»[4], writes Riccardo Massa (1986/2003, p. 75), meaning that it emerges from specific *existences* that involve other *existences*. In other words, it transcends both deterministic and totally unrelated operations, as it is rooted in a local intertwining of existential choices and material, social, and cultural aspects. In this sense, education becomes movement, articulating its activity within limits and possibilities in a concrete relationship with the world. Technoscientific development dialogues with pedagogy in all its *material* contributions through products and discourses, constituting itself as a pervasive and, once again, *existential* dimension of human experience – and therefore of educational experience.

Edgar Morin, referring to the need to reform teaching and thinking reciprocally, emphasizes the importance of learning to grasp the interdependence between the part and the whole (2000). An education aimed at complex thinking recognizes phenomena as multidimensional and interconnected, also legitimizing the conflicting aspects of reality and admitting them into scientific reflection. However, if the education system takes a reductionist perspective and attempts to eliminate disorder by separating problems, the gap between sectoral knowledge and an increasingly multidisciplinary global reality widens (Morin, 2000). Modern epistemology is reflected today in the fragmentation of educational complexity; scenarios are outlined in which bodily and cognitive experiences are separated, students' biographies are broken down into grids and certifications, and learning is imposed by unilaterally transferring predefined information for verification. Such a process presupposes a univocal transfer of knowledge, based on an asymmetry between learner and teacher (Rossi, 2007), distinguished by power relations that are clearly visible in educational settings.

The technological presences with which education is confronted require interpretations that are capable of breaking free from traditional patterns. Thinking of

[4] Translation by the author.

digital artifacts as simple additional elements that 'cause' certain changes (positive or negative) in an environment structured according to the criteria described – and which can therefore be added or removed, or used only as tools for accumulating further disciplinary knowledge – is a limiting view. Within this perspective, if on the one hand a transmissive model is perpetuated, the alternative is to remove such objects from educational spaces because they are considered insidious and dangerous, especially for the most vulnerable people.

However, from a systemic point of view, in educational ecologies, the relationship between humans and technologies develops according to circular and recursive relationships that go beyond the individual component (Alessandri, 2014) because each one transforms and is transformed by the context. Teachers, students, technologies, and knowledge are all elements that interact according to infinite possibilities that intersect, generating a unique and unpredictable exchange. Returning to the field of Social Robotics, these agents fit into this dynamic thanks to their embodied presence and communication skills, challenging pedagogy to rethink the cognitive adventure in light of the presence of different cognitive and bodily systems. For example, it has been noted that the embodiment of robots facilitates understanding of issues related to the physical world, arousing involvement and enjoyment but also greater benefits in learning (Belpaeme et al., 2018). The Child-Robot Interaction research line observes that children seem inclined to relate to robots in ways similar to humans, as they are predisposed to anthropomorphism (Damiano, 2020): it would be anachronistic to shy away from constructive reflection, which is not limited to the illusion of being able to banish technoscientific development.

The plurality of existing technologies, multiplied by the infinite number of human ecologies in which they can be inserted, raises ambitions, fears, and above all, multiple questions. To encourage critical and meaningful design, we need pedagogical reflection that is aware of the epistemological dimensions embodied by technological artifacts – and open to transdisciplinary dialogue.

5. Conclusions

«We have only the world that we bring forth with others, and only love helps us bring it forth», write Maturana and Varela (1984/1992, p. 248), defining love as the *biological foundation of the social*. Furthermore, according to Laura Boella, relationships – which are articulated in encounters with humans or non-humans (objects, places, etc.) – are the core of empathy, the ability to be sensitive to the signals of others (2025). No scientific reflection can ignore this intersubjectivity, since the presence of others is always involved.

The discourse on technoscientific progress is part of a global context inhabited by new forms of oppression and closure, where technologies can become devices for exercising power and the body-mind-environment relationship seems to disappear. Yet, at the same time, all contemporary critical issues – violence, environmental crisis, wars, deprivation, misunderstandings – lead back to human biological roots and questions of coexistence (of all beings that populate the planet). The analysis of technologies must therefore be developed within a framework that brings together *human identity*, in the intertwining of *sapiens* and *demens*, *epistemological aspects*, through which reality is interpreted, and *biological dimensions*, which create constitutive and embodied connections between all living beings.

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