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Ambient intelligence and educational design in digital worlds

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Abstract: This paper explores the transformations of education in the era of intelligent digital environments, proposing an ecological and phenomenological approach to learning. The educational environment is presented as an active agent in the co-construction of subjectivity and knowledge. Drawing on theoretical contributions from Heidegger (1997), von Uexküll (1934), Haraway (2013), and Latour (2009), the text examines how ambient intelligence — conceived as an entanglement of technologies, bodies, affects, and languages — shapes educational experiences. Education is thus understood as a sensitive and responsible act of design, requiring careful attention to the perceptual, temporal, and relational conditions under which knowledge emerges. The metaverse, interfaces, and artificial intelligence are investigated not merely as tools, but as cognitive and narrative environments that orient learning processes (Knox, 2020; Ferraris, 2020). The paper ultimately proposes a rethinking of education as a practice of care for environments, relationships, and possibilities.

Keywords: Ambient Intelligence, Digital Subjectivity, Educational Design, Knowledge Ecologies.

1. Introduction

Educational thought develops within environments that multiply, transform, and take shape through technical mediations and design visions. This contribution follows a trajectory of listening to emerging signals and cultivating environmental sensibilities.

Artificial intelligence appears as a semantic and sensory field in which practices, relationships, and configurations of subjectivity take shape. Education today takes place within such conditions, which unfold across structures, materials, symbols, and rhythms.

Heidegger (1997) reminds us that to dwell means to be immersed in a world that welcomes and addresses us. Design, in this sense, becomes an educational gesture: it shapes the act of dwelling and guides its meanings. Every environment is a web of possibilities involving subjects, technologies, interfaces, and languages. The act of designing implies configuring conditions for experience and care.

The notion of Umwelt, as articulated by von Uexküll (1934), allows us to conceive of the environment as a network of meaning specific to each living being. Berthoz (2008) and Llinás (2009) show that perception, action, and learning emerge through situated interaction between body and world. From this perspective, the

digital environment becomes a perceptual and inhabitable field, a threshold for shared experience.

Haraway (2013) proposes an image of the subject as constructed through relationships and connections—an entity in ongoing transformation, learning and evolving in co-constitution with technologies, materials, images, and both living and synthetic beings. Education partakes in this expanded ecology, assuming the form of a design-based care for the environments that enable feeling, thinking, and acting.

Even the smallest project, according to Latour (2009), holds world-shaping potential. From this view, the educational environment itself is an active and generative project, endowed with sensitivity and compositional force. Dwelling in this space calls for attention to the relationships it harbors, the choices it sustains, and the gestures that make it livable.

This paper offers openings for rethinking education within domains shaped by artificial intelligences, digital environments, and virtual spaces. The map is not fixed but suggests trajectories. To inquire takes the form of orientation, care, and situated gestures: ways of inhabiting contexts with attention and responsibility. Each environment, after all, involves those who act within it, addresses them, and calls them to respond.

2. Ecologies of meaning in educational environments

Every educational environment is a world of relationships — a system of forces, constraints, openings, and possibilities. To speak of environments today is to acknowledge their composite nature: material devices, perceptual and affective forms of experience, technical protocols, signs, infrastructures, and temporal rhythms intersect to produce ecological configurations that shape perception and knowledge.

As von Uexküll's (1934) theory of Umwelt illustrates, the environment is always perceived from an embodied perspective. There is no world "in itself," but rather lived worlds — each constructed from what a subject can perceive, recognize, and act upon. The environment is therefore an integral part of experience, continuous with living and sensing. Berthoz (2008) emphasizes that perception is the outcome of motor anticipation, articulated through movement and the sensorimotor coherence of the subject. In digital environments, this dynamic translates into embodied interaction with devices and interfaces that actively shape cognitive experience.

In digital education, this conception extends. One might speak of a MetaWelt: a layered field of cognitive, sensory, algorithmic, and cultural environments in which educational action takes place. This expanded dimension of the Umwelt highlights how environments — beyond the physical or symbolic — emerge as differential worlds, co-designed by technologies, languages, and practices, where perception, attention, and knowledge are continually modulated. From this perspective, educating means designing environments of meaning: devices capable of activating processes, fostering the emergence of relationships, and supporting the construction of knowledge. There is no learning without context, and no context that is not already imbued with intentionality, materiality, and language.

In educational and digital contexts, this notion gains further relevance: every platform, interface, and digital architecture offers itself as a space of epistemic possibility, each conveying a potential sensory form of knowledge. As Ferraris (2020) writes, the web functions as a real ontological environment, a structure filled with inscriptions, acts, and relationships that contribute to the constitution of society.

Within it, classical categories of reality are transformed and redefined. In this light, the metaverse represents a perceptual and interactive reconfiguration of the real. Ball (2022) observes that future digital spaces will be multisensory and persistent environments, where experience forms part of a digital reality that evolves and endures over time. Interaction here takes the form of immersive experience. These environments become sensitive fields of co-construction, capable of shaping sociality, learning, and self-formation.

The digital, then, forms cognitive experience, reorganizes memory, guides information selection, and modulates attention.

Digital education involves rewriting the modalities through which knowledge is constituted, going beyond the mere transposition of content into networked formats. As Deleuze and Guattari (2021) suggest, every environment activates a semantic and perceptual "capture machine" that acts upon the body and the imagination. Media operate as ontological agents—devices that render visible, possible, and thinkable what we may learn and feel.

The environmental dimension thus emerges as an epistemological threshold. Every environment is a system of affordances, in Gibson's (2014) terms, that suggest, guide, constrain, amplify, or diminish possibilities for action and perception. In digital learning environments, the organization of virtual space, the choice of icons, the rhythm of notifications, and the structure of recommendation algorithms are all components that deeply affect meaning, memory, and emotion. The environment, as such, is never neutral: it acts as a co-agent and participates in the formation of subjectivity. In this sense, it may be understood as both an epistemic and formative space, where perception, memory, affect, and knowledge converge.

As Agamben (2002) affirms, what we call "the open" is always traversed by material and symbolic forces that shape life. Even the most apparently open space, such as the web or the metaverse, is inhabited by perceptual configurations, normative protocols, and attention economies. Openness is always situated. Every environment is both a filter and a map, a locus of possibilities and a threshold of access.

In educational settings, this entails a deep rethinking of design: of tools, relationships, postures, bodies, and memories. The environment is the place where the relationship between knowledge and its participants is negotiated. Sloterdijk (2011) writes that human beings live in emotional, symbolic, and sensory spheres that generate shared intimacy. Education, in this sense, can be understood as a care for these relational and affective spheres.

Within the phenomenological horizon of dwelling, the world takes shape through the very experience of inhabiting it. The environment emerges as a dynamic weave of space, time, gesture, and affect. From this point of view, educating is also an ecological act: one that configures conditions for the emergence of possible forms of life, without imposing singular directions.

As Bergson (1946) suggests, thought is never separate from movement, intuition, and duration. Educational environments are rhythms that generate experiences, and every experience entails a temporal choice, what to allow, what to slow down, what to traverse.

Digital platforms also shape new choreographies of educational time: operational sequences, asynchronous access, interactions punctuated by notifications and metrics. Learning time expands, modulates, and becomes accessible in multiple forms. Space, in turn, becomes a rhythmic composition of presences, expectations, and attentions.

In this lived temporality, and from an ecological and post-phenomenological perspective, the environment is both what happens and the space in which it happens. It is integral to educational experience and its rhythm. The pedagogical implication is profound: education requires environmental awareness. Every didactic choice is an ecological choice. Each environment already contains an epistemic proposal, an affective stance, a situated practice of living.

3. The Interface as an educational environment

Learning unfolds through experiences that engage the body, the senses, environments, and technologies. Cognition is distributed across gestures, rhythms, and the spatial arrangements in which individuals act and perceive, a perspective aligned with Hutchins (1995), who argues that thinking arises from an active network between subject, environment, and tools. Within this distributed view of the mind, digital education relies on contexts that trigger learning through perceptual forms, temporal arrangements, bodily postures, and technological devices.

Cognitive neuroscience demonstrates that brain activity evolves through a continuous dialogue between prediction and adaptation. In this direction, Berthoz (2008) highlights how perceptual and decision-making activities are inseparable from motor simulation and active prediction, dimensions that digital interfaces can amplify or alter through their rhythmic structures.

According to the predictive brain theory (Friston, 2010; Clark, 2013), the mind constantly anticipates future events, adjusting its models based on experience. In this process, learning involves reducing the gap between expectations and reality, generating ever-changing perceptual and conceptual configurations. The brain knows what it has learned to interpret, constructing representations that transform over time. Singer (2010) suggests that perceived reality is a construction shaped by the horizon of meaning sedimented through experience. Llinás (2009) indicates that imagination and perception operate in the same neural space: imagined experiences can activate brain traces similar to those elicited by actual events.

In digital and interactive environments, these cognitive dynamics expand. Interfaces, beyond acting as points of access, actively contribute to the construction of educational gestures. Every click, scroll, and operational choice becomes a micro-ritual through which knowledge is sedimented. Understanding materializes in spaces that blend tactile, visual, auditory, and symbolic elements. Gestures interact with sensors, voices engage with automated recognition systems, and gazes move across windows, layers, and animations.

Haraway (2013) proposes a conception of the learning subject as co-dependent on both material and symbolic environments, where technology and corporeality co-produce experience. Presence thus takes heterogeneous forms: it is mediated, distributed, composed of shared temporalities, modulated attentions, and networked relationships.

Across many educational platforms, spatial organization significantly shapes the learner's subjectivity. Grids, color schemes, loading times, notification settings, and feedback protocols all influence meaning-making processes. Referring to neurodidactics, Rivoltella (2012) emphasizes how digital devices constitute new channels of stimulation and response, shaping cognitive processes.

This vision leads to a notion of the connected body, where the physical dimension intertwines with cognitive processes driven by interaction with environments and

technologies. Every gesture is inscribed in the temporality of the interface, traversing materials and tools that enable the generation of meaning. The interface is not merely a bridge between individual and machine; it functions as an epistemic site, a plane of expression through which knowledge is articulated.

In this scenario, the educational subject emerges as an open figure in constant transformation, shaped by relationships with interfaces, technologies, and environments. As Oosterling suggests in Dasein as Design (2009), existence is formed through projectual acts that interweave body, space, and technique. In digital settings, this design process is continuous: the subject defines itself through the paths it traces, the choices it makes, and the configurations it inhabits. Every environment presents itself as an operational topology, a space designed to enable specific gestures, relationships, and forms of attention.

The notion of the interface must be expanded. Rather than mere technical devices, interfaces are symbolic environments that precondition perceptual and cognitive experiences. The body is reconfigured in the virtual environment: extended through tracked gestures, rhythmic feedback, and interactive protocols. As Husserl (1973) reminds us, intersubjectivity always unfolds within an embodied scene: every experience is filtered through a shared world.

From this perspective, educating means creating environments that activate, modulate, and amplify cognition. Beyond content, it is necessary to generate the conditions in which knowledge can become a sensitive experience. Learning takes shape in spaces where attention is directed, memory is structured, and meaning is distributed.

Latour (2009) invites us to conceive of education as a practice that shapes reality through the care of relationships between the human and the non-human. The learning environment appears as a living organism, an ethical field crossed by tensions between freedom and protocol, openness and structure. The interface holds these forces together, continually articulating new possibilities for subjectivation.

In immersive digital environments, such as augmented reality simulations or shared virtual worlds, perception is distributed along non-linear trajectories. Space expands, stratifies, fragments. Cognitive maps become three-dimensional, and pathways emerge through the simultaneity of stimuli. As Slater and Sanchez-Vives (2016) suggest, these experiences do not detach us from the world; they transform it. One inhabits what one thinks, enacts what one imagines.

A significant example is the design of an immersive virtual classroom in the educational metaverse. Every detail, from spatial layout to avatar movement dynamics, resource accessibility, and interaction timing, contributes to shaping the sensory grammar of the learning experience. The environment emerges as a genuine field of epistemic-affective forces. In this context, pedagogical design assumes the role of orchestrating spaces and temporalities that can support embodied and situated learning.

In navigating across platforms, environments, and tools, the educational subject takes on a fluid form, constantly redefining itself. Each interactive environment is, in this sense, an educational scene, a threshold of experience through which knowledge becomes accessible in the form of a situated presence.

4. Educational design and ambient intelligence

Every educational act entails a form of design. Even in the most informal settings, to educate means to arrange a space, a temporality, and a relationship. In digital and hybrid contexts, this design takes on stratified forms, shaping environmental conditions capable of orienting perception, action, and experience.

Artificial intelligence plays an active role in this configuration. Algorithms, semantic architectures, predictive systems, automation, and neural networks construct cognitive landscapes that accompany, inform, and suggest. AI manifests as a pervasive presence, contributing to the articulation of the learning environment and making visible the entanglement between computation, decision-making, and interpretation.

Knox (2020) proposes to conceive of AI as a cognitive environment: a medial fabric within which attention, knowledge, and relationships take form. From this perspective, education emerges as a generative experience that unfolds in cognitively active environments, crossed by distributed forms of intelligence, not always human.

The design dimension materializes in devices, configurations, and interaction aesthetics, but also in the subtle conditions of presence: access times, movement possibilities, and attention logics shaped by algorithms. Heidegger (1997) identified technology as a mode of revealing the world: what becomes accessible to the mind and body is already the result of choice, form and prefiguration.

Designing digital environments entails acknowledging that every technical choice constructs a world. Interfaces guide actions, codes articulate experiences, and artificial intelligences shape the conditions in which meaning may emerge.

Oosterling (2009) suggests that being takes form through design. This projectual awareness involves multiple dimensions: architectural, semantic, rhythmic, and corporeal. The digital educational environment develops as a grammar of shared actions: a space that modulates possibilities, prepares connections, and expresses an ethic of interaction. Educating within intelligent environments also means recognizing the invisible rules that structure them.

In this direction, Latour (2009) defines design as a philosophical and responsible act. Every platform, every tool, every visual cue educates; the environment becomes both an actor and a partner in the educational relationship. To design, therefore, is to care for the relationships activated by tools, for the attentions they generate, and for the experiences they make possible.

Ambient intelligence, as it takes shape in these contexts, weaves together algorithmic, relational, sensory, and affective dimensions (Floridi, 2014; Latour, 2009; Knox, 2020).

To educate in a world inhabited by ambient intelligences is to interrogate the effects of devices, to decode the hidden languages of platforms, and to restore agency to the subjects involved.

Educational design thus opens up to environmental care: in terms of what is taught and in relation to what can be experienced, sensed, and inhabited. Every environment is a gesture. Every interface is a responsibility. Every project is an invitation to collaboratively construct worlds in which education can manifest as a shared practice of attention and possibility. Each educational space proposes a specific ethic of attention: where we look, with whom we engage, how much we can act. There are no neutral environments, nor architectures without intentionality. In this sense, design is a practice of care, one that arranges possibilities and orients worlds.

5. Thinking of education beyond the present

At the thresholds where the present opens to the possible, education becomes a speculative act. Conceiving education as what can still be imagined implies an epistemological and perceptual shift. Artificial intelligence, as an active and generative environment, accompanies this transformation as a cognitive partner and a device for the reconfiguration of subjectivity.

Subjectivity is constructed through relationships, gestures, mediations, and postures that the environment makes accessible. In digital and immersive contexts, this process becomes pluralized. The self takes the form of a mutable interface, a contact zone between codes, bodies, affects, and languages. Haraway (2013), in her Cyborg Manifesto, had already foreseen how technologies redraw the boundaries of the subject, proposing hybrid figures where the human and non-human intertwine. In the educational sphere, these composite subjectivities become modes of presence, tools for imagining non-linear and distributed learning.

Aligned with Bergson's (1946) notion of the future as coinciding with the creative capacity of thought, speculative education acts accordingly: it abandons predefined maps and opens up previously unseen landscapes in which subjectivity and knowledge co-evolve.

In virtual worlds such as the metaverse, educational space becomes a narrative laboratory, a field of expressive possibilities. Here, speculative practices become pedagogical modes in which knowledge is sensitive, generative, and affective.

The learner in immersive digital environments co-produces, scripts, performs, and enters zones of indeterminacy in which subjectivity expresses itself as continuous transformation (Slater & Sanchez-Vives, 2016). Knowledge is embodied in practices, experiences, and interactions, and learning becomes layered and modular.

This educational approach relies on environments where the body, though decentered, is not excluded, it persists as a trace, an echo of a gesture. Rivoltella (2012) reminds us that all learning is corporeal, even when digitally mediated. Immersive education thus requires renewed attention to extended corporeality: a body that senses, orients itself, and relates through interfaces, latency, and feedback. In intelligent digital environments, the intentionality identified by Husserl (1973) in his phenomenology of intersubjectivity is shared even with artificial agents. Interactions with virtual assistants, simulations, and neural networks generate situated, mediated, and plural forms of intersubjectivity.

In this context, the notion of Umwelt as a psychomotor event, a world inseparable from the gestures that traverse it (Llinás, 2009), invites the design of environments attuned to movement, narration, and error, environments that engage with gestures, positioning, and relationships. There is no learning without the full engagement of the subject, understood as a dynamic center and node of interactions.

Artificial intelligence, thus understood, is a function to be integrated beyond a presence to be interpreted. Every algorithm contributes to shaping the semantic field, acting on relationships, learning rhythms, and thresholds of knowledge access. Speculative education presents itself as a critical and generative stance: a way of inhabiting technologies by questioning, transforming, and rearticulating them in pedagogical terms.

Every educational environment can be read as a fictional device, built through narratives, rules, and codes that determine what appears and what remains implicit. Pedagogical imagination defines the horizon of meaning in such scenarios, through

the creation of narrative environments in which subjectivities may explore, dislocate, and reconfigure themselves.

Agamben (2002) suggests that the human takes form when it comes into relation with what exceeds and challenges it: animality, the machine, the other-than-self. It is through reflection on these boundaries that the human condition is defined, as a continuous process of symbolic and cultural articulation. In digital education, this reflection multiplies: the subject encounters intelligences that do not conform to human norms, but question them, challenge them, and compel redefinition. Speculative learning arises from these frictions, these contacts between living and artificial forms, between presence and simulation. According to von Uexküll (1934), every living being inhabits its own world-environment (Umwelt), constructed based on its perceptual and motor capacities. Digital education follows this same logic: every environment is an Umwelt, a system of possibilities designed according to what one wishes to make visible, actionable, thinkable. From this perspective, the metaverse represents a space for expanding experience, where thresholds between real and virtual intersect as generative sites in which subjectivities can explore new forms of relation and knowing. In these scenarios, knowledge emerges as the effect of a conscious, attentive, and relational presence among diverse agents, multiple intelligences, and intersecting experiential modalities.

6. Educational practices for a conscious environmental design

Thinking about education through the lens of environmental intelligence and digital subjectivity entails a shift in perspective, a transformation in how we understand the perceptual, relational, and symbolic conditions of learning. Education emerges as a situated process that takes shape through the interaction between bodies, environments, technologies, and languages. Learning means inhabiting worlds shaped by sensory and cognitive configurations, where each element contributes to the construction of meaning.

The educational environment plays an active role in shaping experience. Spaces, times, pedagogical architectures, and digital devices function as symbolic and affective operators, shaping cognitive postures, forms of attention, and modes of presence. The interface, going beyond its technical threshold, is redefined as an environment that structures access, relation, and memory. The subjectivity that emerges within these environments is mobile, reticular, and constantly evolving. It is composed of material and immaterial elements (data, affects, codes, gestures). Learning arises from cohabiting with these dimensions, without rigid hierarchies between human and technological, natural and artificial.

Artificial intelligence cannot be reduced to algorithmic functions or predictive logic. It operates within the perceptual fabric of the environment, in logics of selection, and in temporal patterns that structure the experience. As Berthoz (2008) argues, perception is a dynamic process that anticipates and modulates action. Every educational environment that integrates artificial intelligence resonates with these processes, expanding or redirecting them, and thereby contributing to the configuration of formative possibilities.

Education becomes a careful act of design, a practice of responsibility in configuring environments. Designing a learning context means creating the conditions in which knowledge can emerge, shaping rhythms and relationships that enable encounters between subjects, media, and environments. For example, the design of a

hybrid learning space that integrates a flexible physical setting with a modular digital platform can facilitate alternation between synchronous and asynchronous activities, stimulating personalized and situated learning. Every design choice produces effects: it reveals certain trajectories and obscures others; it favors specific modes of participation while inhibiting others. There is no neutrality in educational devices. Every pedagogical gesture is also an environmental gesture; every technological infrastructure orients thought and defines what is possible. A significant example of this design approach is found in adaptive learning environments powered by generative AI and environmental sensors, where lighting, sound, and content arrangement are modulated in real time based on students' emotional and behavioral responses. In such contexts, the environment contributes to constructing learning experience, actively participating in the regulation of attention, the narrative coherence of the educational path, and the relationships among participants.

Environmental intelligence, as a distributed mesh of relationships and processes, permeates spaces, bodies, affects, and technologies. It is manifest in the micro-gestures of interaction, in the thresholds of access, and in the available modes of presence. Educational design thus implies caring for these configurations, cultivating awareness of the codes that shape experience, and attending to the cognitive and sensory ecologies activated in learning contexts.

Within this framework, pedagogy takes the form of an ecology of meaning. Focused on objectives and content, it reshapes the forms that render learning an embodied and shared experience. Knowledge takes form within relationships, in the choreography of exchanges, in the affective dynamics that traverse the environment. Each educational space behaves like a sensitive organism: it listens, responds, filters, and modulates. The learning subject emerges from interaction with a complex field of heterogeneous elements.

Imaginative design plays a crucial role in the construction of educational environments. The ability to envision scenarios, to articulate narratives, to set the conditions for the emergence of the new becomes an integral part of the educational task. Immersive technologies, augmented realities, and neural interfaces present themselves as languages—forms through which worldviews, modes of being, and relational possibilities are constructed. To educate also means to inhabit these languages, explore their implications, and use them to cultivate meaningful presences.

Philosophy, particularly speculative and post-humanist thought, offers essential tools to articulate this perspective. Thinkers such as Haraway (2013), Latour (2009), Sloterdijk (2011), and Agamben (2002) provide frameworks to understand how education is deeply involved in the production of subjectivity, the construction of worlds, and the generation of relations. The educational act becomes an ethical and political gesture, one that designs forms of habitability, produces scenarios of coexistence, and opens possibilities for transformation.

7. Conclusion

Environmental design in education thus calls for a renewed gaze: a sensitivity to modes of presence, to the codes that organize experience, and to the sequences that shape the learning process. Every educational environment function as a threshold, a space in which possibilities are articulated, visibilities are distributed, and configurations of meaning are generated. Pedagogy moves within this liminal space, building

connections, setting conditions, and activating ecologies that allow knowledge to emerge as a shared event.

In this horizon, environmental intelligence finds its deepest expression—not merely in the technical power of networks or the precision of predictive models, but in the capacity to construct complex, sensitive, and situated educational worlds. Every pedagogical act becomes an opportunity to inhabit the world differently, to create transformative relationships, to exercise a shared responsibility in the construction of knowledge.

Ultimately, designing educational worlds means acknowledging that every environment speaks to us: it addresses us, guides us, transforms us. By listening to these voices, education may become a conscious practice of coexistence, care, and shared transformation.

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