Bringing Forth Actions of Learning Through Sensorimotor Experience

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> Context • Despite efforts in education to provide meaningful experiences for students in an educational setting, the challenge remains because most educational models treat learning and knowledge as "something" in the head. These models reject or fail to explore sensorimotor experience as central to learning. **> Problem** • Although enactivists emphasize human sensorimotor experience, it remains unclear how to unfold and conceptualize this experience in learning. Consequently, we aim to outline a better system based on enaction. **> Method** • Using an enactivist theoretical approach, we illustrate how the integration of the motor system into educational settings brings forth our actions of learning. We explore and show what these actions may look like in emerging learning environments where human motricity plays a key role. **> Results** • We understand embodiment as the property that implies and enables the emergence of the personal – in terms of identity and one's lifeworld – as a space and time loaded with affectivity and grounded in motricity. It is configured and reconfigured in such a way that a person has the freedom to choose from multiple potential courses of action at any given moment, whereby being in the present is a prerequisite for these unfolding actions. Therefore, by integrating enactivist principles with pedagogical practice, we propose a shift toward educational environments that respect the complexity of human knowledge. In these environments, the body, emotions, movement, and social resonance, in Rosa's sense, are fundamental to the emergence of understanding. **> Implications** • With our approach we propose that sensorimotor experiences be considered central to all learning, including that which occurs in formal and informal educational settings. We recognize that the learning process is also shaped by interaction within a person's socio-cultural environment, where a shared intentionality can be noted in situated activities that take places in cycles of sensorimotor coupling. **> Constructivist content** • This work aligns with the enactivist approach when learning arises from interaction that takes into account sensorimotor aspects of the human being. **> Key words** • **Affectivity, emotion, learning, motor system, motricity**.

Introduction

« 1 » Since the 17th century, educational practices within formal education have been underpinned by the idea that human beings learn through exposure to "truths" that must be acquired. To this end, a variety of methodologies have been offered, ranging from the delivery of explanations to attentive learners to the carrying out of designed experiments. All of these can be tested and verified through systems that assess the correspondence between what is taught and what is learned (Bowen 1981). In this context, at least 50 years ago, authors such as Paulo Freire (1970) began to criticize the transmission model of education, calling it the "banking model" of education, where learning is measured by the reproduction of content. Similarly, Henry Giroux and Peter McLaren (1989) show that schools should not be understood as places of instruction and knowledge transmission, with schooling oriented toward standardization, homogeneity, and culture control.

« 2 » According to the Organization for Economic Cooperation Development (OECD),[1] the following is expected by 2030/40, in education: knowledge, skills, attitudes and values will be established as core components for achievement, and also as prerequisites for further learning across the entire curriculum. Although efforts are being made to take multiple approaches to education, such as inclusive assessment design, into account, which shift the focus from one-size-fits-all exams to offering diverse ways for students to showcase their learning (Tai et al. 2023), the educational system still operates under the outcome-based model. In this model, testing has become the mechanism for quality control to measure educational progress, and the "factory model of assessment" is the way to do this (Serafini 2002: 67). Therefore, this model often rejects sensorimotor experiences or fails to explore it as central to learning.

« 3 » Approaches such as the Montessori method or the Reggio Emilia School, in early childhood education, challenge this orientation by emphasizing the learner's actions and bodily movements as pivotal to learning rather than focusing solely on results. From the perspective that "all doing is knowing" (Maturana & Varela 1992: 16), education can be understood as a process of

1| OECD Future of Education and Skills 2030 Conceptual learning framework Learning Compass 2030 https://www.oecd.org/content/dam/oecd/en/about/projects/edu/education-2040/1-1-learning-compass/OECD_Learning_Compass_2030_Concept_Note_Series.pdf

constant becoming – an ongoing development in the present, observable in the action of the human being without reliance on preconceived definitions that dictate "how it should be."

« 4 » Moreover, within mathematics education research, enaction has a tradition going back several decades, if not longer (Pirie & Kieren 1989). There are novel approaches related to embodiment designs (Abrahamson 2009, 2014), particularly inclusive designs for mathematics students with sensory impairments. These designs are established by each student through the use of touch (and other senses) with a tactile device (Abrahamson et al. 2019). Currently there is a focus on special-education embodied design, which is articulated through three interrelated parameters: media (artifacts, technologies); modalities, referring to the sensory and bodily channels through which students perceive, act, and coordinate with the environment; and semiotic modes, which include gestures, actions, language, diagrams, and mathematical notations. These modes are sequenced to support the transition from embodied action to formal mathematical reasoning (Videla & Abrahamson 2026).

« 5 » From this view, the human experiences their lifeworld with self-awareness – not as a mere part of this world, but as an essential component of it. This understanding of what it is to learn with awareness in the present can be experienced naturally as an ongoing process in life. However, attempts to unfold the process of learning have generated debates that reveal the ontological or epistemological assumptions underlying the various learning theories. Within this landscape, we adhere to the definition of enaction proposed by Francisco Varela, Evan Thompson and Eleanor Rosch, which consists of two points:

> "(1) perception consists in perceptually guided action and (2) cognitive structures emerge from the recurrent sensorimotor patterns that enable action to be perceptually guided." (Varela, Thompson & Rosch 1991: 173)

« 6 » Our intention in this article is to examine enactive theory and its conception of learning by deepening the discussion of human sensorimotor experience. In particular, we want to explore the sensorimotor patterns that enable action in an educational context.

« 7 » Because enaction has biological and cognitive roots, we propose an analysis regarding the discussion of human multidimensionality. This includes its conditionality of sentient materiality and its possibilities within an educational setting. Our approach offers a distinctive perspective on the learning experience, which from an enactive standpoint includes sensorimotor experience.

Sensorimotor experience and the Umwelt

« 8 » Sensorimotor experience consists of the recurrent coordinations of perception, emotion, and action through which an organism organizes its experience. What an observer distinguishes as the organism's body and environment are conceptual constructs employed to account for these regularities rather than descriptions of an observer-independent reality. Human action may therefore be modeled in terms of biophysical processes, whose value lies in their explanatory and predictive viability. From this perspective, motricity denotes the coordination of bodily movements within the experiential domain that the organism continuously constructs.

« 9 » To paraphrase Maurice Merleau-Ponty (1962), it is through motricity that we unfold as embodied beings. Motricity is the primary sphere in which all meanings originate, however, meaning-making may differ in interactions. This raises the question of how we understand motricity and what distinguishes it that allows us to *scaffold* a perspective that provides new foundational elements for educational contexts, drawn from an enactive approach as introduced and endorsed in Varela, Thompson & Rosch (1991), Thompson (2007), Varela (2016) and Gallagher (2021, 2023).

« 10 » However, thinking about this capacity to move through the body, the coordination of bodily movement in our environment goes beyond considering the central nervous system as a driver that sends impulses to muscles to contract and produce physical movement. For us, it also involves considering the necessity, for the body, of moving according to its own experience. Consequently, learning arises through these bodily movements. In this context, when we speak of learning as an enactive process, we attribute it to the continuous interaction between the body and its environment – a continuous loop that unfolds in a specific environment. Hence the fundamental element lies in the motoric process that is undertaken and executed (Gallagher 2023:140).

« 11 » This implies that the development of an organism is not an invariant process. It is rather a surplus of meaning (Varela 1997: 85) or a surplus of signification (Merleau-Ponty 2003); the added value that goes beyond the physical description of the environment is garnered at each moment. It is where the coordination of bodily movements constantly generates the surplus, giving rise to new movement to reach a new understanding through the body. A good example of this coordination of bodily movement through time is that of infants on their gradual transition from crawling to walking (at around 10 to 18 months). The ultimate unfolding of human potential does not lie in walking as a means of locomotion (this has already been achieved through crawling); however, walking opens up a much wider world, one that transcends mere locomotion.

« 12 » This surplus of meaning enables the organism to learn, thereby constructing what is called its *umwelt*, its unique way to perceive its surroundings. Within the umwelt, relationships between organisms and inanimate objects (e.g., a school building) fluctuate in an aligned manner. Therefore, similar behavior can be observed among those who inhabit the same places, forming what can be called the "identity" of the place (e.g., boarding school, forest school). This "identity," such as the way of walking, speaking, and behaving, can be recognized by those who attend the place, and by those who observe it. For some, the alignment manner could be called "socially situated knowing." However, this perspective is the essential characteristic of living systems: they are self-producing networks that continuously regenerate themselves while maintaining their identity and autonomy (Rudrauf et al. 2003).

« 13 » We can observe how members of a family with similar behavior and shared intentionality form a family, but we cannot say that sisters and brothers are the same, even if they were raised by the same mother and father, and shared intentionality. Likewise, all the members are part of a "situated activity [that] takes the form of cycles of sensorimotor coupling with the environment. What the organism senses is a function of how it moves, and how it moves is a function of what it senses" (Thompson & Varela: 424), yet what an observer notes in this situated activity is determined by our biological constitution, our way of being (Maturana 1988). This highlights that the learning process in each person is shaped by interaction in the socio-cultural environment, and its outcomes imply individuation (Simondon 2022).

« 14 » Similarly, within an educational community composed of participants (teachers, students, tutors, parent), these participants share intentionality, which is usually declared in the educational project of each institution, which is also in line with the political laws and norms of each country and perhaps with some global tendencies. In this context, the community can create and re-create itself through shared collective intentions, but this does not mean that its members will behave similarly.

« 15 » According to Michael Tomasello (2019), fluctuations such as collective intentions create the structure of autonomous identity and the behavioral relationship of shared collective intentionality based on the communities that inhabit them. A classroom filled with students and teachers reflects particular ways of sharing actions, moving their bodies, walking, sitting, interacting and so on. In short, their sensorimotor experiences are coupled with their living, and emergent situations arise from the contingent and immanent intentionality of each person. For this reason, we can observe a similar way of behaving. Our sensorimotor system does not "pick up information," but rather triggers bodily movement, which may be involuntary reflexes or coordinated actions. Certain bodily movements can have practical and instructional significance, such as raising the hand to ask a question or intentionally listening to one another. In disciplines such as physical education, they serve to stress specific techniques required for the respective sports. However, in disciplines such as mathematics or chemistry, it is less common to observe movement as an authentic learning experience.

Figure 1 • Children (aged 4–5) climbing and jumping over a fence. This photo was taken by one of the authors during a research project investigating children's bodily movements and mathematical awareness outside the classroom.

« 16 » In educational settings, the flesh as *Gestalt* of each person carries out actions that express intentionality in its constitutive and constituent encounters with the environment. It displays its unfinished state and presence, as well as its participation in resonance with the context, the place, and what comes next (Rosa 2019; Fuchs 2024). Resonance is a dynamic relationship between the subject and their environment, in which the influence is mutual, bringing about a transformation in both, based on the unavailability of the other (Rosa 2019). For a species, this resonance lies in constructing shared collective intentionalities (Tomasello 2019). However, this intentionality responds to direct and undeniable experiences enacted through the flesh.

« 17 » This element underpins a conception of learning that is based on central interactions that include sensorimotor experience and the collective act of making sense. It contrasts with predominant education models that measure numerical efficiency by the number of people educated. These models ignore or fail to adequately account for the variety of sensorimotor experiences that occur when learning takes places, and how these experiences are meaningful to each individual in their own umwelt.

« 18 » Learning through enaction emerges from interactions with others and the environment. There is no separation between the body and its environment. It is in this intermediate space where cognition exists, and therefore learning takes place. The body, understood not "as a functional system defined in terms of inputs and outputs – as it is for functionalist cognitive science[2] – but rather as an adaptively autonomous and sense-making system" (Thompson 2016: xxvi), becomes the enabling dimension of experience. It adapts or reconfigures itself as a living organism (Fuchs 2024) in every action, from the proprioceptive (Clark 2016) to the exteroceptive and interoceptive, constantly shaped by lived experience – literally living and obtaining experience. In this sense, enaction configures and expresses learning through sensorimotor experience, shown in the patterns of musculoskeletal contraction, thermodynamic and respiratory processes, attentional intensities, balance, and nonverbal expressions that attest to the emotions

2| Hillary Putnam's (1975) functionalism conceives mental states in terms of cause and functional relations. Cause and effect reaction after a stimulus, where cognition is defined by patterns of those functions.

Figure 2 • Sequence of children (aged 4–5) arriving at, climbing and jumping over a fence.

involved in action (Maturana 2021). These vary according to the mastery or domain of the action (Di Paolo, Buhrmann & Barandiaran 2017).

« 19 » Based on what we have said so far, the sensorimotor system plays a central role because learning goes beyond verbalization; it involves making sense through bodily movements. Figure 1 and 2 are taken from an ongoing research project about "Children's bodily movement and their mathematical awareness outside the classroom" in a forest school during free play and walking activities as a part of their curriculum. The children are playing by climbing the fence and jumping once they reach the fourth rail (from the bottom to the top). They did not receive any instruction beforehand, such as "climb the fence." On the contrary, they usually have a walk, which is part of their activities in the educational project.

« 20 » They make sense of the game through their bodily movement and their interaction with the others, climbing,

stretching, reaching the top, and then jumping as shown in the sequence of screenshots from left to right in the video in their first 18 seconds (Figure 2).

« 21 » In the eye of the observer, their learning process can be identified through their constant loop in the sensorimotor coupling with the environment (Thompson & Varela 2001), which is evident in the sensorimotor dimension of how they coordinate with others while engaging in the game in their own way. The children do not climb one after another in a fixed line; instead, each perceives their own body and adjusts to the fence differently. Although each movement is unique, they share a similar intention: to jump (one of the actions). In Figure 1, a boy jumps leading with his right foot while leaving his left foot on the rail. Similarly, a girl also jumps, but she adapts by placing both feet on the rail. Both extend their arms to generate momentum and move through the air. Their extended arms reveal their emotions, showing their effort to maintain balance and their continuous engagement in the situated activity.

« 22 » Are jumping and climbing the only learning taking place? We suspect there are other forms of motion such as those involved in learning how to play the game, waiting for one's turn, and assessing one's limits, but we would like to focus on playing. Following Walter Benjamin's (2015) reasoning, play is the primary arena of repetition through which children transform experience into habit and learning. However, contemporary societal conventions indicate that learning encompasses diverse epistemic and methodological approaches. From an enactive perspective, this diversity can be understood by recognizing that living beings in general, and human beings in particular, are not primarily teachable; rather, they learn through the structural characteristics and conditions found in their constitution, including their bodily movements, as shown in Figure 1 and 2.

« 23 » For this reason, human learning both requires and is expressed through trust: trust in taking risks and, fundamentally, in making mistakes or failing (Dávila & Maturana 2019; Maturana 2021). For children, jumping off the fence involves risk, as they recognize their own sensorimotor possibilities and decide how to take the next step. The observer can see how the children make their decision by observing the movements (their motricity) triggered by their sensory system. As shown in Figure 2, another child decides to climb over the fence instead of jumping over it. This illustrates how each child enacts learning through a distinct bodily response and shows their own distinct way through the movements that express their decisions.

« 24 » So, what does this tell us? Learning is an exercise of constitutive freedom whose outcome is a structural change aimed at conservating and maintaining the organism–niche relation (Maturana & Verden-Zöller 2008). In other words, learning is configured by the process of constructing and constituting personal-social existence. This means that we choose to learn what resonates with our organic, cultural, and existential conditions. In this process, we observe that an operative moral and ethical sense is at play, which acts as a whole both personally and socially, taking turns to respect one another with each jump.

« 25 » Figure 1 and 2 demonstrate how the children's learning is configured through the game, which is central to sensorimotor experience. It is a process of becoming and making sense of their own learning. They master their movements throughout the activity process, showing their own domain of action without any standardization of the perfect bodily movement. However, the process of becoming implies understanding. We will discuss this point in the next section.

Process of becoming in understanding

« 26 » From a broad perspective, and considering the multiple relations that constitute the human being in the present, understanding is unfolding as the core of the educational process (López Melero et al. 2003; Maturana 2021). As Merleau-Ponty (1962: 144) states: "To understand is to experience the harmony between what we aim at and what is given, between the intention and the performance – and the body is our anchorage in a world." Therefore, the experiences that shape our understanding of daily actions involve bodily movements that rely on our sensorimotor activity and motricity for carrying out those actions. In an educational setting, the process of learning usually unfolds in a sitting position (Figure 3). This is the traditional educational setting of the 20th century. Furthermore, it is recognized that many students are still being taught using outdated pedagogical practices and a school structure that no longer meet the educational needs of the 21st century (Schleicher 2018).

« 27 » Practices such as sitting for long periods to listen to a lecture or solve a problem according to the instructions given by a teacher overlook the involvement of multiple bodily movements in learning. Additionally, a study by Emma Norris and colleagues (2020) about the impact of physically active lessons shows that those students who spend more time on physical activity perform better academically than the students who sit for prolonged periods. Moreover, although it is recognized that sitting for long periods of time adversely affects health, there is a cultural tradition that prevents students from standing up and stretching in the middle of class (Cowgill et al. 2021).

« 28 » In situations such as sitting in a classroom, we find ourselves radically situated in the time and space that constitute the unfolding action. According to Humberto Maturana and Varela (1984), this results in an articulated experience that produces a radical structural coupling, which affects the distinctive feature of human life, namely understanding. Therefore, the relationship that articulates the existence of a sentient being is challenged by the interactions that occur in educational settings, in particular, in the classroom.

« 29 » Specifically, in human experience, this means understanding that we are constitutive beings: We are a species that becomes through our relationships with specific landscapes and environments. These relationships create relational flows in which emotional resonance also emerges (Rosa 2019). Such emotional resonance can be observed in bodily postures, a topic that has received less attention in educational settings. Instead, these settings have focused more on verbal expression, which often disadvantages those whose development differs (Ferreira 2021; Macrine & Fugate 2021).

Figure 3 • Students (aged 12–13) in a mathematics class. This photo is from one of the authors' research project about re-observing the emergence of mathematical learning from an enactivist perspective.

Being present at educational settings

« 30 » From the experience of daily living and of being in educational scenarios, it is intuitively clear to us that we exist in a condition of ongoing organic dynamics through the interactions and the relationships that define the existence of a being when learning occurs within education. These dynamics arise from biophysical processes such as the act of breathing, the permanent thermodynamic exchange and the operation within an environment that both contains us and enables and conditions us to feel and act. Feeling cold in the morning, sweating in the afternoon or during repeated exercise, or feeling tired in the evening are examples of existential organic and metabolic characteristics that are constitutive of daily life.

« 31 » We call them constitutive because they are more than functional capacities to perform an action. They also show that the outcome of any action is the confluence of the agent's structural characteristics and conditions in the time and place where they find themselves, as well as the ongoing process or loop between perception and action (Valdés-Zorrilla, Letelier & Soto-Andrade 2023). The presence of meaning stems from the dynamics that are organically configured from what is organically felt, involving both a historical and cultural becoming and the novelty of the emergent aesthesis (Gallagher 2021).

Learning and motricity

« 32 » According to Maturana (2021), *learning* is a form of training, not in the sense of instruction but as an act of doing that requires constancy and permanence in order to stabilize a behavioral configuration that clearly approaches the construction of an *habitude* (Merleau-Ponty 1962). This *habitude* is best expressed when the pleasure of mindfulness and awareness is recognized (Varela, Thompson & Rosch 1991). We emphasize this point, because mindfulness and awareness are the most important gains from the experience: although the performativity of the experience may vary, the sense of pleasure and/or enjoyment in what has happened, as well the sense of fulfillment as a being in relation to the situation, remain. Hence, within the emotion of pleasure or joy and its collective expression, it is important to recognize joy as a positive space and time. In everyday life, this is manifested through play and dance, i.e., aspects that are shared across different cultures (Maturana & Verden-Zöller 2008) and are therefore natural epistemic expressions in humans that demonstrate that learning emerges from joy.

« 33 » Knowledge, by contrast, is configured as a way of life. It ranges from the most routine and ongoing tasks to the more exclusive and accidental forms, strengthening or nurturing ways of doing. Therefore, knowledge is what we do to maintain and constitute our way of living because, as we discussed previously, knowing is doing. It is a loop that provides the conditions, modes, accents, nutrients and symbols that orient and sustain the organism's ability to operate. These elements organize and give meaning and significance to one's way of life or lifestyle.

« 34 » What stands out here is the significance and understanding that emerge from becoming conscious of what has been learned. However, it is important to remember that consciousness cannot exist in a void – without meaning, embodiment and experience. In this context, significance is always shared: "by becoming conscious of a thing or relation, we understand something about it" (Durt 2017: 68). Significance refers to the relevance of aspects of an object or relation as experienced by the observer under particular conditions and structures. It works as a double anchor: on the one hand, it is coupled with a shared world or culture and, on the other, it is anchored in or coupled with one's own sense of self – one's embodied presence.

« 35 » Once knowledge is configured, the possibility of renewing, creating or exploring deliberate forms of experiences that broaden, deepen or optimize ways of life in any of its relational flows or domains becomes a natural or fluid opportunity. In simple terms, whoever holds knowledge in a particular domain of doing can identify, evaluate and configure new ways of operating within that field. Once the individual has achieved the balance and thrust necessary to ride the bicycle within the dynamics of repeated and variable displacement – much like the impetus or desire to improve – they can further their levels of mastery (Dreyfus & Dreyfus 1986).

« 36 » In this sense, learning from motricity refers to an understanding of radical enaction as a proposal that describes the process of constituting one's lifeworld as a relationship of complex and systemic organisms, whose meaning and significance emerge from the experience of being an embodied being that is affected and affects a constitutive relationship with one's umwelt. We can observe these relations in various individual and collective activities. For example, in a game, dance or dynamic movements, the result can be understood from a personal perspective. That is, nobody learns exactly the same thing as the person next to them. At the same time, however, we recognize that learning is shaped by the environment, that can be named community/social, school, forest or other collective forms of association. In other words, no one learns effectively in solitude or without a supportive environment.

« 37 » All the options expressed by the person performing any action reflect personalized and individualized expressions. Their actions also express the exploratory, constructive and symbolic dimensions of any activity (Gabler, Nistch & Singer 2000). For example, raising a hand to say hello is an action that shows a meaning situated in a particular place. The person and their preceding culture are constituted and recreated in their present actions by the conditions of the action and its intentionality. In this context, when one raises a hand, another person may reply by raising theirs to say hello.

Unfolding human sensorimotor experience in learning

« 38 » Experience as a phenomenon has long been a topic of discussion, but, for the purposes of this article, we will focus on a phenomenological and enactive perspective, drawing on Anthony Clarke (2025) in reference to *The Embodied Mind*, the influential work of Varela, Thompson and Rosch (1991). From this view, the condition of the embodied mind is found in a sort of chiasmus between the visible and invisible (Merleau-Ponty 1969).

« 39 » Figure 4 illustrates, from our enactivist perspective, human motricity in action in specific operative terms in daily experience. In this context, we understand *operationalizing* as an action of coordination that makes it possible to remain engaged in the action. For example, Maturana (1987, 1995 and Maturana & Verden-Zöller 2008) defines languaging as "operating in a network of consensual coordinations of consensual coordinations of behaviors."

« 40 » Beyond the operant intentionality expressed by Merleau-Ponty (1969), bodily movement and motricity imply the construction and constitution of a world according to the conditions imposed by the environment and the structural characteristics of the human being on the social dimension, both phylogenetically and ontogenetically. The here and now is immersed in cultural elements and configurations that provide more or less defined modes depending on the community or culture in which one is situated. Therefore, human meaning and mode emerge from the relationships or configurations produced in specific environments where they are operating, based on what individuals are able to do, and how they constitute their umwelt through emotional resonance (Rosa 2019; Fuchs 2024).

« 41 » This process of manifestation (Henry 1973) – that which becomes present in itself – marks presence and living as a way toward operationalization in an edu-

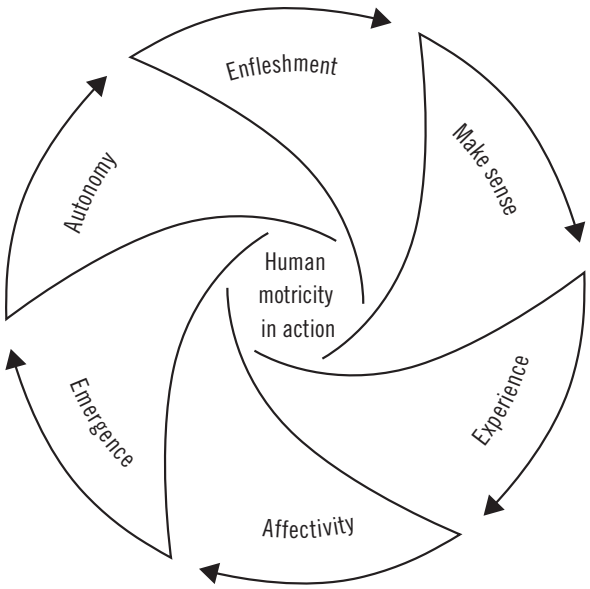

Figure 4 • Constituents of human sensorimotor (based on Toro-Arévalo et al. 2022).

cational context. Drawing on work by Di Paolo, Cuffari & De Jaegher (2018), in our understanding of the human condition in relation to education, this translates into the following – observable – cultural dimensions:

- *Enfleshment* as the intermediate and dynamic property that occurs between the living and the symbolic, forming a two-dimensional fabric: organic on the one hand and cultural on the other, the first situated in metabolic and homeostatic processes, the second in the relational configurations that arise from the sensitivity of the living being in community and social life.
- *Affectivity* as the dimension that expresses the state and mode in which embodiment – through its sensitive and mobilizing properties, both centrifugal and centripetal, from neuromuscular to global – unfolds identity and supports the agency of individuation.
- *Autonomy* as the particular process of agency of the living being, enabling the construction of life through structural and co-dependent engagement with the environment.
- *Emergence* as the construction and ongoing constitution of the environment, both shared and personal, shaped by historical situations and contingencies, while also being oriented towards projective ways of life and horizons that favor structural coupling and autopoiesis.
- *Experience* as a consolidation of lived experience and the basis for learning or development from the embodied mind, including the affective imprint of the experience that lets it decant into a surplus of meaning, marking an event in one's personal life and/or shared life.
- *Making sense* as the transient result of experience that enables the interpretation and evaluation of action and behavior. Making sense reveal the fusion between development and behavior. What is learned shapes and structures ways of doing and being in one's personal and shared life, constituting both a world and an identity.

« 42 » Based on these dimensions, the action of learning – when unfolded– can be understood as a flow of interactions that demarcates distinct aspects or moments in human development. This is especially noteworthy if we consider it as a path that is traveled on a daily basis, such as in the case of those children who were jumping over the fence (Figure 1 and 2), or those students who were sitting in the classroom (Figure 3). The educational context requires clarity to ensure that its effort, beyond standardized results, supports the formation of a human coexistence that addresses different states and situations of living. What we mean is that education in general, and school, in particular, have ignored or overlooked the learner's experience in terms of its authenticity and sensorimotor origins, and their manifestation into the cultural dimensions shown above. It considers these experiences solely in terms of the outcomes defined by adults. Even a teacher could overlook or ignore their own experience as a person in a situated relational context. Yet they must not ignore human experience (Frank, Gleiser & Thompson 2024); rather, they must recognize and reveal it as the path to learning and knowledge.

« 43 » We can distinguish between an educational space and education as a constitutive experience of being. An educational space, whether formal or informal, can be understood as a space meant to offer experiences for each sentient being who forms part of it, fostering the possibility of perceiving actions specifically selected for that space and context. This often explains why certain experiences fail. They lead to unsuccessful actions when suggested or implemented without filtering by those responsible for generating the conditions of the experience. Each location has unique conditions and is therefore irreproducible.

Dispositions that resonate in us

« 44 » What role does the school play as a formal space and a temporal framework for promoting learning? Among other far-reaching possibilities, it can set the course for one of two outcomes:

A It hinders the learning experience by promoting standardized knowledge acquisition, where forms of measurement disregard the individual as a learner and reduce them to someone who reiterates prescribed knowledge;

B It paves the way for learning as an original act that integrates the individual with the social, and generates the conditions for a space between "I" and "the other" through the careful selection of appropriate actions for each encounter.

Option B would ideally require constant self-awareness and awareness in every action. It involves observing how the system is operating, and recognizing at least some manifestation of human sensorimotor experience and how it resonates in us.

« 45 » All of this takes place in the consciousness of a human being rather than in the body, mind or consciousness as separate functioning parts of a whole (as in the machine-body view), but in the embodied being. In a fluid and original way, learning is an embodied experience generated in constant circularity (Figure 5).

« 46 » When learning takes place, an organic and relational phenomenon arises among those who are experiencing it (whether consciously or unconsciously), which can be referred to as the learning process. The term "process" should not be understood as a straightforward intention. On the contrary, it unfolds within a circularity in which certain dispositions such as trust, emotion or social sense resonate with that learning process. These resonances, shown in Figure 5, can be conceptualized by an observer who notes the emotional, social, or existential aspects involved in learning. The resonance of these dynamics arises in their umwelt wherever knowledge is brought forth for those who are interacting.

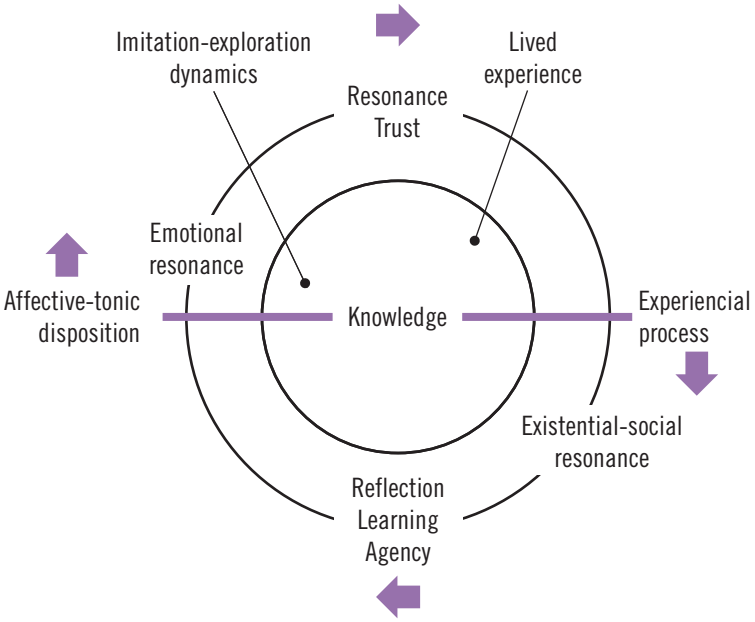

Figure 5 • Learning as an organic and relational phenomenon. Arrows and circles indicate a constant flow of becoming of knowing and doing. Lines indicate possible patterns of action in human experience. The circularity of the vectors and the continuity of the image convey the dynamism with which the elements characteristic of human motricity in action are expressed.

« 47 » We claim that learning involves many interactions among its participants as the umwelt flourishes and the milestones shown in Figure 5 become apparent. Since the human being is an embodied being, their relationship with the environment emerges in every situation and at every age through a *tonic-emotional dialogue* (Wallon 1984). This dialogue implies that being present in the situation at hand is the first indicator of the action that unfolds. Being present gives us the freedom to choose our actions in line with our sensorimotor experience in an educational context. Paying attention to detailed interaction with others is where learning takes place. Without resisting what is happening in the moment, we accept that is not possible to control everything – such as mistakes when solving an equation in a mathematics class – and remain open to fully experiencing all aspects of education that teach us as well. For we must recognize that in every educational system, we learn from one another. A teacher also learns from their students.

« 48 » What characterizes this moment of action is its fundamentally pre-reflexive dimension, grounded in the immediacy of existence (Quay 2013: xx) and in affective resonance (Rosa 2019; Fuchs 2024), which can be observed as emotional resonance (as shown in Figure 5), which is generated in the situation and in the presence of two or more beings, human or non-human. In childhood, resonance can be observed when imitation emerges as a response to the emotional bond between a child and an adult (for example, a teacher) with whom the child continually interacts and who is, in some way, responsible for the action that, in an educational setting, generates the emotion of curiosity, interest or relevance. This is direct experience of the action being imitated or explored: the leap or shift toward experience arising from a surplus of meaning (Varela 2016), which is grounded in the emotional implication of the experience. Therefore, resonance at this stage presupposes an already stable and purposeful bond. This is the emergence of a relational flow that supports the recognition of both the situation and those who are part of it.

« 49 » However, we note that there are some challenges to consider in connection with the emergence of any relational resonance. Although we can observe that "when we sense an emotion in another person, it resonates within us, we make it our own" (Castellanos 2024: 47, our translation), the sense of that emotion that resonates within us requires a constant living in the present. Otherwise, how can we recognize what resonates within us? This also implies taking into account our sensorimotor abilities, as the body is also actively engaged in the actions.

« 50 » Following this, another challenge is the *imitation and/or exploration* of desired behaviors of peers, equals or role models, which reveals the mirror-like condition inherent in mammals. In an educational context, where different individuals are participating in the experience of learning, this imitation could be understood as an adaptive behavior to the circumstances in which the participants are living. A student or teacher is adapting to school (for better or for worse) as well as to the educational conditions presented to them in their experience.

« 51 » Experience requires a particular condition, i.e., a state of interest to act that is not yet fully available, but that holds the possibility of acting. In this context, identifying what makes a difference within experience requires awareness of the moment. However, if the educational model continues to resemble a factory, where learning is a "production line," sensorimotor experience will be encouraged less or receive less attention. This results in fewer opportunities to modify the state of the individual undergoing the experience, which generates resonance (Rosa 2019), and thus the desire to return to what has occurred in order to make it available to oneself based on the generated context or situation.

Discussion

« 52 » From an enactivist perspective, we can recognize that when learning is understood as interaction within what we call an educational space, such as a school, this implies the vital participation of those who inhabit that space with their entire being, including their motricity and unfolding movement as an essential component of learning. In this context, enaction theory encourages us to rethink learning, considering that what we perceive is determined by what we do (Nöe 2010: 1) and that "doing" is also emerging in our sensorimotor patterns (Varela, Thompson & Rosch 1991: 172).

« 53 » However, what if, in educational settings, we lack an awareness of the present? A present in which the interactions, including our motricity, are taken for granted in every subject area. A present in which the sensorimotor aspect is invisible or perhaps does not receive sufficient attention in the pedagogical context. As a result, the managing of education in general becomes an alienation or mere simulation of intentionalities and purposes that are located within the context of people and communities, and may even constitute a more or less forced incorporation of external interests.

« 54 » We noted that the absence of the present creates the appearance of learning and the appearance of deepening knowledge. In practice, however, it amounts to nothing more than a superficial evocation of data and knowledge. This is because there is no space in which these can unfold and no "with whom" that constitutes the community necessary for learning. Likewise, less attention has been paid to the body and its motricity as an authentic learning action across different domains of action, with priority given instead to coordination among participants (teachers and students) through verbalization in a single, ongoing, directional discourse with occasional exchanges of dialogue.

« 55 » Our understanding of one another evolves without our being aware of our resonances and ways of being. There is a risk of denying our human constitution, where the body, emotions, and social resonance are fundamental to the emergence of understanding.

« 56 » Just as the body does not exclusively feel and suffer, nor does discourse exclusively organize and create worlds, it is the person – the embodied being – who feels, suffers, communicates, move, creates worlds from their materiality and immateriality, their presence and focus, and their enactive unfolding.

Conclusion

« 57 » As part of our theoretical research, we have argued that education can recover if those involved in it appreciate this vision of a circular, reflexive and recursive process, which is conveyed to us by enaction, acknowledging the way human sensorimotor experience is a constituent part of any knowledge or discipline in an educational setting. Furthermore, we considered that sensorimotor experiences are central to any learning. Neither learning nor what is learned takes place in isolation or in a self-referential way.

« 58 » We understand embodiment as the property that implies and enables the emergence of the personal in terms of identity and one's lifeworld as a space and time loaded with affect and grounded in motricity in which each person configures and re-configures their choices in the course of action.

« 59 » Finally, we acknowledge the future implications of this enactivist approach. Our proposal to take sensorimotor experiences into account as central to any learning, in particular in an educational setting, brings forth other challenges. These include the design of pedagogical approaches and the role of the observer in perceiving bodily movements as authentic learning (Ramirez 2025).

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Competing interests

We declare that we have no competing interests.

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We declare that we have not used any generative AI tools to write this article.

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This target article is part of a bigger picture that encompasses several open peer commentaries and the response to these commentaries. You can read these accompanying texts on the following pages (or, if you have only the target article, follow the embedded link that takes you to the journal's web page from which you can download these texts).

Open Peer Commentaries

on Paola Ramírez et al.'s "Bringing Forth Actions of Learning Through Sensorimotor Experience"

When We Observe Light and Shadow, What Do We Learn?

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> Abstract • I draw on the notion of the umwelt to offer a complementary example of how to incorporate exploratory sensorimotor experience-based learning into mathematics-education contexts. I also consider the interplay between learning and measurements of learning and raise a question about the tension therein.

« 1 » In their target article, Paola Ramírez, Sergio Toro Arévalo and Javier Vega Ramírez make a compelling case that sensorimotor experience is both crucial to fostering learning and an often-overlooked aspect of the learning process as it is modeled by and put into practice in educational settings. The article is visually summarized by a juxtaposition of pictures: photographs of children playing (Figure 1 and 2); photographs of children sitting in mathematics class (Figure 3). Citing Humberto Maturana and Gerda Verden-Zöller (2008), the authors observe that, "Learning is an exercise of constitutive freedom" (§24).

« 2 » As a canonical archetype of formal educational settings, compulsory public schools, by contrast, are anything but free (Cohen 2011). They are systems of rules and structures and people that are ostensibly working together to safely and securely educate children. In practice, whether or how schools foster learning is the subject of spirited, ongoing debate. The authors contribute a critical perspective to this debate – an enactive view that centers motricity as, "[…] the primary sphere in which all meanings originate" (§9). They argue that sensorimotor experience, as a basis for learning, is all but absent from "educational models that measure numerical efficiency by the number of people educated," insofar as, "[t]hese models ignore or fail to adequately account for the variety of sensorimotor experiences that occur when learning takes place […]" (§17). Below, I offer a concurrence to their critique and a question about the attainability of their vision.

« 3 » Ramírez, Toro and Vega introduce the notion of the *umwelt,* an organism's "unique way to perceive its surroundings" (§12). In my own work as a mathematics teacher, I continually look for learning designs that might foster opportunities for students to experience the exploratory, constitutive freedom that catalyzes learning. The analysis presented in the target article was thus deeply resonant for me. A central focus of my work as a mathematics teacher is to reconnect the doing and knowing of math-

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