

## Systemic Thinking in Education and a Situated Perspective on Teaching

### Pensamento Sistêmico em Educação e a Perspectiva do Ensino Situado

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**Abstract:** How can the complexity of the school crisis be faced? How can a static and closed model of knowledge be overcome in favour of openness, flexibility, plurality and change? How can we not offer simple solutions to a complex problem? In this article, we present some paths forward in the search of answers to these questions. The first proposal is for us to overcome the dualistic relationship between subject and environment, considering both as part of a single ecosystem, based on the symbiosis between respective elements. The second proposal is for us to take our gaze away from the ecosystem through an ecological approach, for us to perceive the immersion of the subject in the respective environment. Finally, we propose deepening the existing relationships in the ecosystem, to understand its interconnected structure. In conclusion, we tackle the concept of situated teaching, as a practical application of the presented reflections.

**Keywords:** Systemic thinking; Ecosystem; School environment; Situated teaching.

**Resumo:** Como a complexidade da crise escolar pode ser enfrentada? Como um modelo estático e fechado de conhecimento pode ser superado em favor da abertura, da flexibilidade, da pluralidade e da mudança? Como podemos oferecer soluções não simples para um problema complexo? Neste artigo apresentamos alguns caminhos a seguir na busca de respostas para essas perguntas. A primeira proposta é superarmos a relação dualística entre sujeito e meio ambiente, considerando ambos como parte de um único ecossistema, com base na simbiose entre os respectivos elementos. A segunda proposta é desviar o olhar do ecossistema através de uma abordagem ecológica, para perceber a imersão do sujeito no respectivo ambiente. Por fim, propomos aprofundar as relações existentes no ecossistema, para entender sua estrutura interconectada. Concluindo, abordamos o conceito de ensino situado, como uma aplicação prática das reflexões apresentadas.

**Palavras-chave:** Pensamento sistêmico; Ecossistema; Meio ambiente escolar; Ensino situado.

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## Introduction

Discourses on technologies, methods and rhetoric focused on the centrality of the learner subject fill up the current debate on education. Standing out is the generational gap between digital migrant teachers and native students, accustomed to dealing with the culture of our times and the obsolescence of a school incapable of responding to social demands. As such, *innovative* teaching techniques are proposed as solutions to the school crisis, without, however, questioning the specificity of the context in which education occurs and the relationship of dependency/autonomy that the subject has with the environment in which is immersed.

We argue that educational innovation is only possible if we adopt an ecological approach to the problems marking the school crisis. It is about making an epistemic effort that considers the complexity of education topics and respective interconnections. There are still no clear indications of methods capable of meeting this challenge, but there are attempts to create alternative paths with respect to the current educational system, which is still based on the modern paradigm of science and scientific knowledge.

This means taking the focus off techniques and responsibilities and directing attention in studies to the culture of our times. As for didactics and its need to reinvent itself, in the face of digital culture, we believe that it requires an exercise in humility to admit that one does not know the fruit of the teaching activities undertaken and, at the same time, in courage to test complex paths without a pre-determined destination.

From a systemic perspective, according to the French philosopher Edgar Morin (MORIN, 2011), every action evades the intentions of the individual undertaking it. Action presumes complexity, that is, chance, the unforeseen, enterprise, decision, awareness of divergence and transformations. This does not mean, however, that didactics is left to chance or involves lack of planning. The difference is in guiding action through strategy, rather than a plan. Strategy, Morin continues, allows us to initiate an action based on a decision, foresee a possible number of scenarios and modify them according to the information that the situation entails and according to the unexpected events altering the action itself. This idea is very close to the concept of reflexivity of teachers, dear to literature in the area of education over the last few decades.

The recognition of complexity in education does not justify the inactivity, frustration and insecurity that teachers experience in the face of new digital culture scenarios. Awareness of complexity can be the driver for truly innovative action, action that is not based on pre-established techniques and models, but is inspired by the ideas of others always seeking their situated application.

## Facing Complexity

Edgar Morin (MORIN, 2014) proposes that dealing with complexity means confronting conceptions scientifically ignored for a long time. Among them is the concept of autonomy and, with it, the notion of subject. As the author explains, interest in the subject was suffocated in classical scientific thinking. For centuries, science has chosen to separate the observer from his or her observation in the name of promoting the relationship of linearity between cause and effect. Morin (2014) asks: "Who is the subject?" Since the 17<sup>th</sup> century,

the subject has been banished from the scientific process and has had respective subjectivity undermined to give way to objective knowledge. However, to get it back, it is not enough to dwell on it and conceive it as an entity detached from the environment. This is because the systemic perspective, that is, the way we perceive ourselves intertwined with each other and the context, is what underlies living organization. Put another way, we are beings dependent on the external environment, in the same way that it derives from our action.

And why is it important to get back autonomy, which is impracticable from a deterministic perspective, within the context of systemic thinking? Because this idea of subject is based on the notion of living beings interacting with their environment, that is, it involves, at the same time, emancipation and dependence. As such, according to the principle that Morin defines as self-eco-organization, an autonomous living being does not exist separate from its biophysical environment. But even though this environment is *within* living beings, such as a cell or an organ of our body, they are still autonomous. In this complex relationship, speaking of the self-eco-organization of autonomous living beings means understanding that the organization of the external world is part of our own living organization, etched in ourselves.

The example that Morin uses to show this external man-world connection is that of the circadian rhythm. Based on biology, the idea is that we have an internal biological clock that registers in our organism the chronological organization of the Earth. This clock regulates, for example, our sleep schedules and the release of hormones like melatonin.

The relationship with the environment lies precisely in this rate between increased melatonin levels and night-time darkness. A topic awarded the Nobel Prize in Medicine in 2017, with the use of technologies, the circadian rhythm and the intertwining of our biological clock with the organization of the environment becomes even more complex. This reinforces Morin's idea that we are part of a self-eco-organization.

In short, the idea that we are self-eco-organized is based on a conception that, at first, can only be presented as a paradox: that *our autonomy is inseparable from our dependence on the environment*. In other words, the more autonomous we seek to be, the more dependent on the environment we have to be.

As stated by the French botanist Gilles Clément (CLÉMENT, 2015, p. 65-66, our translation), this process can be described as a relationship of symbiosis between man and the environment:

Symbiosis applies to the absolute interdependence of two beings or two systems that are biologically connected. Humanity depends entirely on the diversity it exploits, but in the course of its evolution it reaches a point where the very environment – hence diversity – becomes dependent on humanity.

Based on a complex systemic thought, the quest for autonomy reprises in this effort what Morin (2014, p. 48, our translation) calls ecological dependence, according to which “[...] we are products and producers, in a rotating cycle of life”. In this cycle, there is dialogue and conflict between man and nature, and the perception that we affect each other mutually.

Based on this awareness, we realize that the very idea of knowledge changes, because it is not a matter of obtaining *domain over* nature, but rather of giving rise to *dialogue with* nature (CLÉMENT, 2015). For this to be possible, we must seek to experience a condition of immersion in the environment to which we belong/are interconnected, which requires

humility and at the same time daring and courage. This condition is possible thanks to an ecological vision of the man-world system. The ecological metaphor is consolidated in the search for ways, which are still uncommon, that help to overcome the impasse of separation between man and nature, nature and culture, man and context, among other separations. In all areas and approaches that use the ecological metaphor as a way to obtain an ecological theory and go beyond (SCOLARI, 2015), the prospect seems to be that of a production of knowledge not *about*, but *with* something or someone.

It is worth highlighting here some of the elements that constitute common foundations of ecological and systemic thinking. In this way, the ecological metaphor can help us think about education and, more directly, reflect on contemporary didactics and its relationship with cultural artefacts.

Etymologically, ecology is the 'study of the environment' (from the Greek *oikós*, 'house of living beings' and *logos*, 'study'). From an ecological perspective, we can perceive a certain influence of systems and cybernetics theory, as evidenced in the search for integrating different processes of the technical, social and communicative sphere<sup>1</sup>. The common basis lies in the bearing of attention on relations between the components of a given system and not on the components themselves. In this sense, the primordial norm is interconnection, which helps us to perceive reality as a concatenation arranged in such a way that each element of the system constitutes the other, and both are always immersed in a context. These relations, entailing great complexity, develop dependencies and mutual, non-linear and dialogical determinisms that encompass both a macro level, that is, social changes in ecosystems, and a micro level, with cognitive and perceptual changes in the subjects (SCOLARI, 2015).

Why use the ecological metaphor? As Kuhn (1998) shows, the function of metaphors is to help us to understand and explain the existing paradigm and thus help us in the search for a new theoretical, methodological and conceptual model based on it. According to the author, the metaphor refers to "[...] all those cognitive processes in which juxtaposition, whether of terms or of concrete examples, gives rise to a network of similarities that helps determine the way language connects with the world" (KUHN, 2006, p. 252, our translation).

The metaphor of an *ecology* is an important strategy not only for the academic and scientific discourse of communication in interfacing with education, but, in general, for understanding the interconnected scenario of which we are part. In the interest of social and human sciences, some disciplines seek the ecological metaphor to question the (old) split between subject and object, and to think about the interaction of human beings with the environment. Out of these specificities, we can mention Ecological Anthropology, with a new exponent in the form of Tim Ingold (INGOLD, 2000) based on his thoughts; Ecological Psychology, and the contributions of James Gibson (GIBSON, 1986); Ecological Philosophy, or Ecosophy, a term created by the French philosopher Felix Guattari (GUATARI, 1990) with contributions from thinkers such as the French sociologist Michel Maffesoli (MAFFESOLI, 2017), as well as the Ecology of Knowledge by Boaventura Sousa Santos (SANTOS, 2006). Despite the specificities of each area, the use of the ecological metaphor seeks to express the awareness of a network structure that contemplates multiple interactions, whose focus is on the (re-)establishment of the ecological relationship of the subject-object.

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<sup>1</sup>This approach alludes in particular to the precursory thoughts of Harold Innis (1894-1952), Lewis Mumford (1895-1990) and Gregory Bateson (1904-1980).

Linking all the fields and intertwining the interests is what Maffesoli (2017, p. 10, our translation) calls ecological sensitivity, that is, "[...] *instituting* attitude, in the nascent state, which can be described as *holistic*". This perspective, the author says,

[...] entails organic thought, which, above and beyond the hierarchies, separations or habitual distinctions of established sociology, is bound to recognize the multiple and necessary interactivities, action-retroactions of reality as a whole. (MAFFESOLI, 2017, p. 10, our translation).

Upon suggesting a model of *orchestral communication*, under which participating subjects adapt themselves and adjust to communication mutually in the search for common understanding, as in an orchestra, the anthropologist and multidisciplinary scholar Gregory Bateson (BATESON, 1977, 1993) proposes an approach that highlights communicative standards. He emphasizes the pragmatic bias of interaction regarding the semantics and syntax of the message. In this way, the author (re-)includes in the communicative process elements such as gesture, touch, smells, movement, space and time, considering communication as an *integrated whole* (WINKIN, 1998) encompassing both verbal and non-verbal communication. In this situation, the actors' relationship is the main theme of socially shared actions; interaction that can only be considered when we adopt *systemic thinking*.

From the perspective of interconnected architecture, based on changes in communication and the cognition of subjects, the physical universe is understood as a dynamic web of interrelated objects and events. The physicist Fritjof Capra (CAPRA, 1997) explains: no single part is fundamental, and the overall consistency of the web determines its structure.

In the understanding of the existence of a network among the units that compose the ecosystem, we perceive that the idea of knowledge is increasingly linked to the meaning, since the construction of meanings does not arise based on the perception or understanding of isolated facts or objects: the interconnections, the synthetic images are a condition for the possibility of such processes.

### **The School as an Open, Dynamic and Complex System**

In order for us to overcome the causality of the educational structure based on Cartesian principles, one option is to consider the school as a social system and therefore complex and dynamic. According to Charlot (2006, p. 16, our translation), the school is a social institution, subject to policies under which "[...] students and teachers act within an institutional framework that determines material, financial and bureaucratic conditions". However, he cares little about communicational and relational issues.

Thinking about the school as a social system and therefore vested in all its complexity means, in our view, to perceive its dynamics beyond the scientific dimension, but obviously without ignoring it. In other words, it is necessary to insert in this dimension the relationships that occur in ourselves and in our daily life intertwined with nature, thereby recovering, as we saw in the previous chapter, ecological and systemic awareness.

To understand how the school can be considered an open and complex system, we must first briefly introduce the concept of system.

## ***The System and Its Characteristics***

The notion of system is due to the German biologist Ludwig von Bertalanffy, who in 1937 developed *General Systems Theory*, published in the 1950s. The theory sought a common denominator for all branches of science investigating living systems, it being evident that certain principles of scientific research were valid and applicable in all spheres of knowledge.

In Von Bertalanffy's (1950) definition, a system is a set and a combination of dynamically related, interdependent elements, which constitute an activity to achieve a purpose, a constant goal. Systems can be closed, if they do not exchange with the surrounding environment (as is the case with a machine, for example a clock), or open if they have influential relationships with the environment, operating with incoming information, matter and energy and supplying the result thereof after processing that presumes transformation. Living systems, such as a cell, plant, or organization, are part of this latter category. If on the one hand a closed system is in a state of equilibrium, an open system is characterized by its instability (MORIN, 2011).

Besides the interdependence of parts and exchange with the external environment, there are other elements that characterize an open system. Among them, we briefly point out: (1) the impossibility of deterministic forecasting regarding respective behaviour; (2) the existence of self-regulatory mechanisms, such as self-correction of errors (morphogenesis), the constant demand for external energy for the survival of the organism, maintenance of constancy in the exchange of imported and exported energy, and the ability to overcome external disturbances (resilience); (3) the existence of subsystems within the general system, the regulation of respective limits and the differentiation of the functions of each constituent part (VON BERTALANFFY, 1950).

The famous phrase that sums up these characteristics – *the whole is greater than the sum of its parts* – was coined within the German movement called Gestalt. In German, *gestalt* means *form* or *aspect*. The central point of this concept is that we perceive the entities based on their properties as an integral *entity* (the whole), and not based on the isolated properties (the parts).

In line with this thought, the American mathematician Edward Lorenz (LORENZ, 1963) points out that although we use research methodologies of modern science in which we divide the study of living beings into separate objects, we must always keep in mind that they are complete entities and that they must be analysed, for a real understanding of their operation, in a holistic way, as a synergistic whole. The shift from the analytical focus of the research objects to the study of objects as a whole can in fact be seen as a rupture in the scientific paradigm of modern science, a change in terms of methodology and epistemology.

From the perspective of complexity, Maturana and Varela (2001) consider that systems – be they biological, mechanical or social – are at the same time organized and organizers of a structure whose functioning is also structured and structuring. With this conception, what defines a social system and, therefore, also the school, is its organization, whose interest lies in the interactions engaged in there and not in the elements themselves. In this way, *organization*, from a systemic and complex perspective, can be understood as the relationship or set of relationships between the components of a system and their relationship with the environment. On the other hand, *structure* is proposed as current interactions between current components of the system.

According to Bateson's (1993) definition, a system is any unit that includes a *feedback* structure, therefore capable of processing information. In this sense, the system is a set of elements integrated through communication in such a way that, in order to understand its components, it is also necessary to understand the ways in which they relate or communicate with each other. With his centrality in communication, unlike Maturana and Varela, Bateson adopts a perspective that considers the communication and relational system as an open system. As we have seen, this will be the basis for the consideration of orchestration in interactions.

### ***The School as a Complex System***

In 2004, the Brazilian researcher Ricardo Tescarolo (TESCAROLO, 2004) published the book sharing the same title as this section, *The school as a complex system*, which we refer to here for the purposes of our analysis on didactics and technologies.

Remarking on the school as a social system, the author points out that organization is what gives it identity. Its characteristics and interactions determine its essence, nature and, therefore, also its imbalance. For him, considering the school as a social system means taking it not just based on its specific organization, but based on its unique structure and functioning. In this regard, it is necessary to define what is understood by organization and, along with that, by school structure so as to reflect then on how to overcome the crisis of this organization.

According to the author, both the organization and structure of a social system "[...] constitute the history of its development, which in turn represents the result of the interactions between the system and its social environment" (TESCAROLO, 2004, p. 78, our translation). On the one hand, when we think about the crisis of a school organization, we must question the characteristics of segregation, selection and homogeneity, acquired and maintained since the 18<sup>th</sup> century, in light of the need to embrace heterogeneity, diversity and multi-dimensionality, valuing the combination of biological, social and cultural aspects that the contemporary scenario demands. We may think that this is where its instability lies.

On the other hand, the structure of the school relates to how the components are ordered and how their dynamics intercede in the interaction and in the domain of each one. This is where, for example, the introduction of digital technologies in school, one of the current imperatives of the innovation discourse is placed. The adoption of tablets instead of exercise books is only a current component of the school (structure) that in no way interferes with matters of segregation, selection, homogeneity and linearity of the school institution (organization). In the same way, *new* and *active* methodologies can even alter the school structure – for example, expanding the classroom by allowing students to explore the school environment or by proposing that they expound their questions in *chatrooms* and discussion forums – but do not modify its organization, that is, the set of relations that constitute it.

In short, we can say that a new technology can change the school structure without, however, significantly modifying its character, its identity. We can think of other examples: the focus on a curriculum based on abilities or skills for the 21<sup>st</sup> century, or on the four pillars of education pointed out by the Délors (1994) report. These are elements capable of changing the *structure* of the school, without, however, touching upon the foundations of its *organization*.

As proposed by Tescarolo (2004, p. 91, our translation), although composed of different human agents, the school "[...] establishes its orientation towards a goal resulting from the movement of human action within it". In other words, it will be necessary for teachers, students and the environment to agree in the search for a new perspective, or new school organization, which encompasses not only the material aspect, but also social and cultural aspects.

For change to be sustainable, we need to interweave structural changes with the other elements that make up the *school* environment. This is because, contrary to what one imagines, changes in the structure of the social system will, to some extent, cause the organization not only not to change, but to preserve its initial characteristics.

As affirmed by Morin (2011, p. 22, our translation), "[...] the intelligibility of the system must be found, not just in the system itself, but also in its relationship with the environment [...], this relationship is not mere dependence, it is determinative of the system".

The crisis in school organization is not essentially educational, capable of being resolved with new methodologies presented as models or *recipes*, nor does it concern only economic needs, which can be resolved by adopting technologies and/or by including educational processes in the digital environment. It is necessary to consider the school in all its complexity and, therefore, to focus in the foreground on human action as the "[...] only instance capable of constructing an open logical system of reference and promoting the development of respective relations" (TESCAROLO, 2004, p. 86, our translation). It is in the interactions between subjects, which constitute the set of properties and define its organization, that one must invest.

Complexity, Morin (2011) reaffirms, always presumes a part of uncertainty, originating not only from our limits of understanding, but also etched in the same phenomena that occur within richly organized systems, whose order, however, is inseparable from chance. When we talk about cultural integration of ICT in education, we need to understand that school management, internet connection, equipment, teachers, students, parents, physical spaces, educational practices, infrastructure, relationships, skills, knowledge, contents, methods, techniques and instruments are the parts of an open, dynamic and complex system, an integrated and situated whole, 'greater than the sum of its parts' whose evolution over time is uncertain and unpredictable.

### **Interconnected Architecture and the Classroom**

In the context of communication, the interest of an interactive network perspective began in studies that gave rise to cybernetics in the 1940s. As part of them, scholars from various areas sought to question the linear representation of information, and came to think of it as communication flows. In the field of social and human sciences, Bateson (1977) began a discussion about the nature of characterization of interactions between subjects and between them and the environment based on the qualitative and systemic slant of communication. With the characteristics of social and human sciences, Bateson's point of view can be considered as a counterpoint to the deterministic view of the mathematical theory of communication. Developed by two mathematical engineers, Claude Shannon and Warren Weaver, in 1949, in this perspective communication is understood as a linear process of transmitting a message, encoded in a signal, by a transmitter, through a channel, to a receiver. (SHANNON; WEAVER, 1949).



Following this approach, Bateson (1977) worked with concepts such as system, context, ecological mind/ecology of the mind, among others that comprise an important framework for questioning certain habitual meanings for interaction and for communication itself. In this way, he and other authors interested in understanding a system through the interaction of its components took as a starting point that it was necessary to shift the focus on individuals to pay more attention to the flows of communication patterns in order to perceive how they are able to change this same system. In the words of Bateson: the patterns which connect.

As such, according to the interconnected perspective, what matters is the interactions. Based on them, a system – be it a person, an organization or a forest, is always interacting with other systems. This interaction causes the system to undergo a change in its organization. Within this changing environment, the output the system possesses is to be equally flexible, thereby adapting and self-organizing, letting itself be influenced by the environment and at the same time influencing it. Otherwise, the tendency is to disappear.

Returning to what we discussed in the previous section, adopting this perspective involves the development of an ecological consciousness. At school, having an ecological consciousness means considering it as an environment composed of multiple interactions. Likewise, this perspective is tied to seeking to see, with more clarity, the existence of an interconnected architecture and the transformations caused by digital networks. As such, understanding the principles that underlie interconnected architecture is of great importance for understanding the classroom as an ecosystem.

In order to step up to this debate, it is necessary for the field of education as a whole, and for didactics in particular, to take on the commitment as a greater transformation than simply adopting new methodologies and seeking innovative practices. This understanding will only be possible if there is what Bachelard defined as *epistemological break*.

The Italian communicologist Massimo Di Felice (DI FELICE, 2012) points out that we can think of interconnected architecture both as *interconnected information architecture* and as *cognitive architecture*. Based on the thinking of Bateson, Maturana, Varela and others, the idea of *interconnected information architecture* is what allows all interacting parties to communicate in a horizontal way, giving them the same power dissemination and participation. On the other hand, in *cognitive architecture* focus lies on the conception supporting the production of meaning, which is derived from the embodied experience of the subject in/with the world. Information-related and/or cognitive both translate into a systemic flow of interactions between various elements, which, in turn, are in continuous communication.

From the perspective of a subject-environment system based on feedback, that is, on the flow of information between the units that compose it, we perceive the importance of understanding the ways in which they communicate with each other. The idea of feedback means that interaction occurs through communication and vice versa. Nevertheless, communication is ultimately responsible for shaping the system, or systems integrating systems as a whole, and the environment. Therefore, as part of this idea, the linear model of communication – in which a transmitter (centre) is responsible for transmitting a message that will be picked up by a (secondary) receiver – loses its apparent coherence.

As an exercise in the search for an integrated view of communication, Bateson (1993, p. 331) suggests that we use in the descriptions of interacting objects the key expression "part of". With this approach, the focus is on communication relationships established within a

context, immersed in the environment, in which all phenomena should be considered relevant for their understanding. In this regard, investigating a certain interaction in terms of systems, according to the author, is synonymous with a presentation of relations and communication patterns that occur in a given context of complete circuits, it (the context) being part of a system in constant mutation and therefore open.

Characterized by circularity, by mutual affectation and by multiplicity in levels of interaction, it is the flexibility of the system – from human to social fabric – that ensures its dynamic nature. In a general sense, Bateson's (1977) ecological epistemology sought to expand the mind, focusing its research on communication within evolutionary processes, whether of humans or amoebas. With this interest, communication immersed in a context has as its main role being the "glue"(SAMAIN, 2004), or the pattern that ties (BATESON, 1977) living beings to the interconnected structure, besides the environment being for production and the exchange of meaning.

With his ecological approach, Bateson (1977) proposed a systemic and relational form of thinking that extrapolated individual boundaries in the construction and dissemination of knowledge. For him, this form of knowledge is not new, being nothing more than a characteristic of living beings. Capable of overcoming the Cartesian view and body/mind separation, under this conception of ecology of mind, the mind is not enclosed within the brain; it lies in relationships and expands causing transformations in both the environment and the system which, at the same time as transmitting a message, also receives it. These are movements that evidence system-environment interdependence and its interconnected architecture.

By the mid-1960s, both the thinking of Bateson and that of other authors related to cybernetics were the basis for the construction of *artificial* systems-environments configured as interconnected information architecture. The most significant case is the creation of Arpanet, a forerunner of the Internet that we know and use today (DI FELICE, 2012). Observing the characteristics considered as unique of this new interconnected architecture, we realize that, technologically, it resonates with the concepts proclaimed in Bateson's (1977) thinking. Among them are: the overcoming of the linear communication structure (transmitter-receiver), the absence of a centre responsible for disseminating information, the expansion of access and disclosure of information and, above all, the shaping of interconnected information architecture – approaching the orchestral communication model (BATESON, 1977, 1993), as we explained at the beginning of this chapter.

Another important reference for considering interconnected architectures in the interest of education and didactics concerns cognition. Returning to the thinking of Maturana and Varela (2001), cognition cannot be considered as the result of an internal event of an ecosystem, nor does it represent the result of an external reality. Being circular, a learning system happens through a circular process, in which a living organism responds to the stimuli from the environment, thereby altering itself; based on such changes, it changes its behaviour.

As considered by the authors, a living being has an initial structure with which it establishes various interactions with the environment, which, in turn, also features its own dynamics. In this interaction marked by mutual disruptions, the reciprocity between organism and environment is what is responsible for the changes in their structures without losing their organization. In this way, the conception of *structural coupling* is closely linked to the ontogeny of the living being.

The structure can be understood as the components and relations that actually constitute a particular unit and shape its organization. In this case, the organization is "[...] the relationships that must occur between the components of something, so that it is possible to recognize it as a member of a specific class" (MATURANA; VARELA, 2001, p. 54, our translation). With this idea, Maturana and Varela question the conception of representation, that is, a formulation citing the nervous system as a channel where organisms capture information from the environment for the construction of the world. With emphasis on interaction and on the idea of nervous system expansion, the authors affirm that

[...] on the one hand, we can consider a system within the domain of the functioning of its components, within the scope of its internal states and structural modifications. Based on this *modus operandi*, for the internal dynamics of the system, the environment does not exist, it is irrelevant. On the other hand, we can also consider a unit according to respective interactions with the environment, and describe the history of its interrelationships with the environment. From this perspective – under which the observer can establish relations between certain characteristics of the environment and the behaviour of the unit – the internal dynamics of the latter is irrelevant. [...]. We take cognizance of these two perspectives and correlate them in a more comprehensive domain established by us. In this way, we need not resort to representations or deny that the nervous system functions in an environment commensurate thereto, as a result of its structural coupling history (MATURANA; VARELA, 2001, p. 150-151, our translation).

Despite the differences, especially in relation to Bateson's explicit focus on communication, his conception and that of Maturana and Varela have in common the interconnected idea of the knowledge acquisition process. More specifically, the network-based, interactional structure proposed by the authors features common characteristics such as non-linearity, circularity, non-centrality and randomness. Besides these, the conception that we are part of an ecosystem in an active way and not just as observers, also marks the understanding of interconnected architecture.

In the specific case of education, the importance of the conception of interconnected architecture – in informational and cognitive terms – lies in its possibility of delineating new ways not only of explaining, but of thinking about the complexity and its social connection qualities. In other words, we must convert the structure into a network in the interest of a systemic thinking that encompasses social aspects.

We advocate adopting this perspective in pedagogical and didactic terms, linked to the constitution of the problems in a dynamic way, that is to say, not only attributed to the people concerned – teacher or students – whether as an organization (such as the school) or as a particular group.

The expectation is that, based on the metaphor of knowledge as a network, a broad spectrum of teaching actions can be redesigned, involving both didactic activities in the strict sense and those referring to evaluation processes, planning, curriculum organization and the use of educational technologies, among others (MACHADO, 2002, p. 32, our translation).

The analysis of traditional teaching practice presented by Nilson Machado explains some fundamental critical points regarding the possibility of creating an interconnected architecture in the classroom and understanding knowledge as a network of meanings. Firstly, the author points out that the hegemonic approach in pedagogy is that leading from the abstract to the concrete. According to Machado (2002, p. 41, our translation), abstractions cannot be considered either as a starting point or as an end destination:

[...] they are situated in the middle of the process; they constitute necessary midpoints, never beginning or end. Consciously or not, concrete reality is always situated on the threshold of cognitive processes; knowledge arises from what is real and aims for it permanently.

For this reason, the author continues, to achieve knowledge, the pure and simple transmission of information is not enough. It is necessary to establish connections between information, to process them and to organize them into systems, in a constant process of symbiotic interconnection between teaching discourse, teaching action and knowledge conception. Planning a class following the conception of knowledge as a web of meaningful bonds and relationships, for example, would result in the choice of few subjects, chosen on the basis of their scope of articulation, aggregation and catalysis. As affirmed by Machado (2002), subject specializations are often excessive and almost always precocious, and do not favour a dynamic understanding of the relations between the parts and the whole.

In terms of didactic activities, the idea of interconnected architecture in the classroom means resorting to useful tools in terms of the synthesis of contents and unprecedented articulations, for an understanding of nodal interrelations between meanings. According to the author, the metaphor is the cognitive instrument that is most conducive to triggering associative processes that become knowledge.

### **Situated Teaching**

It is worth emphasizing two aspects, when we think about the use of ICT in the school environment as mediators of the teaching and learning process and beyond the instrumentalization. The first one is related to the understanding that people create and negotiate their relationships with each other each time they interact and communicate. The second one concerns the perception of continuous relationships as co-evolution, which occurs through words, gestures, body movements and behaviours exchanged during interaction, i.e. in contact with others and with the environment.

For Bateson (1977), co-evolution is the ability to modify, in a relational and reciprocal way that occurs in the interaction between systems. In this regard, it mainly involves a recursive transformation of systems and of these systems with their environment – acting and operating as an entity of interaction, in the same way as the organism (subject) that occupies it. Bringing the matter to the realm of didactics, we agree with Rossi (2011), when he considers the *classroom as a system*, a privileged 'place' in which co-evolution takes place with mutual influencing, which has implications for knowledge and learning.

Below we propose a way forward as part of didactics that considers the classroom as an ecosystem. The ideas are open and may inspire teachers to engage in teaching actions that are both humble and courageous. They make up what we define as situated learning.

As we have seen, proposing that the school take on interconnected architecture – notably interactional and active – means considering diversity as a fundamental part of the system, not a minor, or troublesome issue. This means considering the singularity of each student without trying to diminish the multiplicity of underlying relationships between subjects and the environment – one of the most important characteristics of a new form of education based on the ecosystem approach. In this scenario, the effort must be made to consider particularities and individual (economic, political and sociocultural) differences without, however, focusing only on respective differences.

In this way, the enactive approach seeks to embrace diversity, taking it as a source of embodied, situated and shared knowledge. This means that the construction of *knowledge* depends on the kind of experience resulting from possessing a body that has different sensory-motor skills and is part of a broader biological, psychological and sociocultural context. We will seek here to delineate how, through an 'enactive lens', it is possible to observe the relational and learning dynamics from an ecosystem perspective – under which difference is a possibility, not an obstacle.

But what is enaction and why is it important for didactics?

Considered as a repercussion from the conception of autopoiesis, coined by Maturana and Varela in the 1970s, enaction theory, or enative theory has as part of its core meaning the understanding of cognition as an incorporated and collective process. For Varela, Thompson and Rosch (2003), knowledge is produced in embodied experience *with* the world, and not in the representation or codification of it. In other words, the production of meaning and knowledge happens when we establish a sensory-motor action *with* the environment, coupling ourselves with what surrounds us.

Upon drawing attention to active and lived cognition, under this perspective, perception and action are essentially inseparable. It is in this regard that, according to our point of view, enactive theory becomes relevant to education. Upon considering that *cognition cannot be taken as mere problem-solving through representations, but rather as the emergence in the creation of a world, education becomes a common action* for which everyone is responsible.

Bringing enactive theory into the fold of didactics, Italian educator Pier Giuseppe Rossi (ROSSI, 2011) takes the concept of structural coupling – interactions that trigger changes in the structure of a given system – as the basis for enactive teaching. According to Rossi, enactive theory presumes two aspects when associated with human formation: one related to the centrality of action and another to the consideration of the classroom as a system. In the first one, the basis of action theory considers that the subject and the environment are transformed during action, which makes this change the basis of mutually constructed knowledge. In this way, "[...] knowledge transforms itself during the reciprocal transformation that comes from action" (ROSSI, 2011, p. 82, our translation). In this case, as a mutually influencing phenomenon that has implications on knowledge and learning, this action represents co-evolution.

The second definition that Rossi (2011) presents concerns the transformation of the classroom into a system, a *classroom-system*. In this case, as a context that opens up to structural coupling, the classroom as a system acts as a 'trigger'. In other words, the environment stimulates learning, action and the construction of situated meaning. To this end, the Italian professor emphasizes that "[...] the classroom system is transformed during teaching [...] according to its own rule and on the basis of its structure, which is not the simple sum of components" (ROSSI, 2011, p. 83, our translation).

As such, under the enactive perspective of didactics, it is necessary to bear in mind that the environment does not produce a mechanical change in the classroom system, that is, the rules and elements of the environment are not decisive for the organization of the system. In this sense, as we have discussed previously, just including technologies in the classroom will not lead to a change in didactics. The transformation that occurs during teaching happens through relationships that combine changes in the environment and the current state of school facilities. In this regard, based on enactive theory, teaching itself does not produce knowledge. It is knowledge itself.

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