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Systems and Knowledge

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SYSTEMS AND KNOWLEDGE

General introduction

Knowledge is intrinsically tied to systematicity. To know something means synthetizing multiple pieces of information into a coherent whole. Systematicity is not just a matter of order or clarity but a necessary condition for universality too: because science is a collective endeavor, we must grasp the deeper structure of our knowledge to check its compatibility with new and different theories. Today's interest in pluralism, perspectivism and relativism invites us to rethink systematicity, and to consider different frameworks of philosophical knowledge. Far from being a merely epistemological issue, questioning the relationship between systematicity and knowledge entails asking whether and how knowledge discloses a systematicity already present in reality or, rather, imposes it upon reality, as well as inquiring into what kind of systems may best remain faithful to different ontological domains.

The 8th International Doctoral Conference in Philosophy and Education Sciences aims to undertake a collective examination of the concept of systematicity, considering its philosophical and pedagogical dimensions. The objective is to critically assess the role of systematic thinking in the constitution, transformation, and possible fragmentation of knowledge, as well as its implications for philosophy and education sciences. To this end, the conference is organized into thematic panels specifically designed to encourage scholarly dialogue and foster interdisciplinary exchange between History of Philosophy, Theoretical Philosophy, Political Philosophy and Education Sciences.

Political Philosophy

A case for AI's history: Neats vs. Scruffies, Two Competing System Ontologies

Giulio Amore, Università degli Studi di Padova

Within AI studies, the Neats versus Scruffies dichotomy (McCorduck 2004; Russell &Norvig2022) distinguishes two different approaches to system building and in the end two different philosophies of systems. On one side, Neats believe that optimal systems emerge from discovering fundamental rules or methods providing logical coherence and clear verification. On the other side, Scruffies combine diverse methodologies pragmatically, and functional success is the primary goal.

In AI's history, there were periods where one of the two approaches achieved the best results, for example: symbolic AI(which was the prominent approach in the '50s and '60s, while not the only one) was a clear success of neat formalism, although connectionism and especially robotics revived scruffy emergence; later on, in the mid-to-late '70s and '80s, the success of expert systems and even more of machine learning techniques played in favor of Neats' approach. In the present scenario, Russell and Norvig(2022) observe a new scruffy resurgence: even if contemporary LLMs are built in a "Neats" way, they require extensive training and fine-tuning phases, which lays down to Scruffies' approach. From a more general point of view, we could say that the Neats' approach is more theoretical, while the Scruffies' is more empirical. In the end, the philosophical interrogation becomes: does a system function because it is well-formed, or is it well-formed because it functions?

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Algorithmic Governance as Information Warfare: The Daily Interface Effect of Digital Violence
Valerio Specchio, Università degli Studi di Napoli "Federico II"

This proposal reads algorithmic governance as an *antropological ethos* build *on* and *developing* information warfare. Far from being neutral system of efficiency or optimization, algorithmic goverance operates as digital infrastructures that need to amplify the transparency of the world (through digital datification) and, a the same time, systematically producing and expanding opacity within platform society. Reading algorithmic goverance as information warfare allows to examinate not only explicit conflicts of disinformation or cyber-security but also the daily *interface effect* of algorithmic infrastructures as digital violence within political, economic and social life. The proposal argues that algorithmic governance, within platform society, can be read as informational warfare build on *epistemic consupmtion* and *cognitive proletarization* where datification and algorithmic profiling redefine the political conditions of individual and collective knowledge.

Immanent Critique and Totality: The Method of Critical Theory Between System and Knowledge

Samuele Cantori, Università degli Studi di Perugia

Reflecting on society has meant, since the modern age, grappling with the idea of a system understood as a totality. From Hegel to Marx, up to Durkheim, the notion that collective life is not reducible to a mere juxtaposition of individuals, but forms an ensemble endowed with internal coherence, allowed social analysis to escape fragmentary empiricism. It is therefore unsurprising that the first generation of the Frankfurt School, particularly Horkheimer and Adorno, adopted this perspective against specialized positivism, developing a holistic and dialectical vision of the social. However, what in Lukács and the early Frankfurt School appeared as an emancipatory promise begins to fracture in Adorno. Totality is revealed no longer as an epistemic principle, but as an ideological construct, a coercive form of *identifizierende Denken: das Ganze ist das Unwahre*.

This contribution aims to show that such a shift does not entail abandoning all systematic approaches, but rather opening a new theoretical field. Critiquing the classical notion of totality does not mean rejecting the possibility of thinking society holistically: it implies distinguishing between the Hegelian-Lukácsian totality—a unified and logically necessary whole—and a critical holism that recognizes the real interdependence of social phenomena without reducing them to a closed order.

Within this framework, *immanent critique* constitutes the privileged method of Critical Theory. It relies on the Hegelian notion of *determinate negation*, which enables it to evade both the externalist critique—judging reality from a transcendent and counterfactual standpoint—and the internalist approach, reduced to hermeneutic contextualism. For the Frankfurt School, immanent critique inhabits the tensions of society itself, while at the same time transcending the given to preserve a margin of emancipation: that is, it must derive a form of *transcendence from immanence* based on the gap between given and norm.

Theoretical knowledge abandons the closed system, but does not renounce capturing interdependencies between phenomena: truth manifests in fractures and tensions, without reducing social complexity to a coercive synthesis. Critical holism becomes the intermediate path between fragmentary dissolution and coercive totality—a rationality capable of reconciling complexity and negativity while keeping alive the emancipatory ambition of Critical Theory.

Grand Tour, geomorphology and Terra Nullius: Enlightenment aesthetics and the time of landscapes

Kathryn Weir Université, Paris 8 / Università degli studi di Bari Aldo Moro

Tracing connections between the art of the Grand Tour in the 18th and 19th centuries and the expropriation by colonial powers of southern territories through the notion of *terra nullius*, this presentation will consider how the philosophical, aesthetic and iconographic apparatus of the Enlightenment and of European imperialism contribute to the creation of the division between human beings who are subjects of history and those who are dehumanised and rendered objects. The emerging scopic regimes underlying the interwoven phenomena of Enlightenment science and colonisation not only structure the gaze but create the seeing subject as the only one capable of interpreting the landscape and writing history. The discussion will take as its starting point the cartography of aesthetics proposed by Kant in the *Critique of Judgement*. It will analyse the construction of sensibility with reference to northern European visitors to the south of the Italian peninsula after the discovery of Herculaneum and Pompeii, as well as to the celebrated appearance between Sicily and Tunisiain 1831of the volcanic island of Ferdinandea, in the context of debates raging across various nascent scientific disciplines concerning the mechanisms and timescales involved in shaping the earth

History of Philosophy

The Conception of Mathematical Sciences as a System in Aristotle's *Posterior Analytics*

Andrés Rivera Arizabaleta, Université Paris 1 Panthéon-Sorbonne

Demonstration (ἀπόδειξις), which constitutes scientific knowledge in the strict sense as defined by Aristotle, proceeds from principles proper to the genus of the object to which the deduction (συλλογισμὸς) applies. The Aristotelian prohibition on demonstrating "by crossing from another genus" (ἐξ ἄλλου γένους μεταβάντα) stated in Posterior Analytics I, 7 admits an exception: it is possible to construct demonstrations concerning the harmonic properties of natural beings on the basis of arithmetical principles and demonstrations, just as it is possible to prove their mechanical properties on the basis of geometrical principles and demonstrations. Thus the mathematical sciences (understood in the broad ancient sense encompassing not only arithmetic and geometry, but also optics, harmonics, mechanics, and astronomy) seem to offer Aristotle an example of a systematic articulation of different kinds of knowledge—which are "common" in that they study Beingunder the aspect of quantity—and one that makes it possible to escape the disciplinary confinement to which the principle of the incommunicability of genera appeared to condemn them. This is possible only insofar as there exists a relation of subordination among the various disciplines. How are we to interpret this hierarchical relation that makes possible the application of mathematical principles to the study of empirical reality? Does it already amount to a systematic understanding of the relations that the propositions of these disciplines bear to one another?

I will examine the groundings of a systematic conception of the mathematical sciences which emerges in the background of Aristotle's account of the conditions of scientific knowledge. Whether by virtue of their "purity" (in the manner in which they consider their objects and their relation to experience) or their "exactness" (ἀκρίβεια), mathematical disciplines appear to be organized hierarchically—a hierarchy that says nothing about an axiological ordering of these disciplines, but that reveals the epistemological stakes that arise when one attempts to apply mathematical principles to the study of physical reality.

Analytical Method and Architectonic Principles in Leibniz's *Système nouveau*

Giacomo Manzi, Università degli studi di Roma Tre

In the final chapter of *Nouveaux essais sur l'entendement humain*, Théophile/Leibniz asserts that all truths can be organized using two methods: a synthetic-theoretical method, in which the order of truths is established through proofs that rely on primitive and indemonstrable notions; an analytical-practical method, following a teleological arrangement that guides knowledge as a means to achieve human happiness. In this presentation, I will examine this analytical method and argue that it provides a framework for understanding how Leibniz organizes truths within an open system, aimed at producing hypotheses for resolving the difficulties encountered in the experience of phenomena. The form of the system that emerges from the Leibnizian analytical method is a nexus of hypothetical–conditional knowledge possessing a probabilistic epistemic value, in which hypotheses can be evaluated and modified according to the architectonic principles that guide scientific inquiry. Examples of these principles include the principle of sufficient reason, the continuity principle, and the principle *de maximis et minimis*.

Following this interpretation, I will argue that this analytical approach to the organization of knowledge is particularly useful for understanding Leibniz's metaphysical theses, as presented in his 1695 essay *Système nouveau de la nature et de la communication des substances*, published in the *Journal des savants*. This raises the question of how epistemic architectonic principles can be related to the discovery of the metaphysical foundations of phenomena, and how this inquiry is connected to the practical pursuit of human happiness.

The Systematic and Rhetorical Nature of Knowledge in the Philosophy of C.A. Helvétius
Francesco Piccardi, Université Marie et Louis Pasteur

In Helvétius' works, a system defines philosophical, religious and political views organized in a coherent whole of principles, the notion being often polemically employed to discredit such views. Nevertheless, and despite an apparent asystemacity of Helvétius' discourse, I will argue that:

a) On one hand, systematic thinking plays a key role in Helvétius' philosophical project. Throughout an internalist reading of the texts deploying precise conceptual categories (such thoseof *principle, fact, demonstration, deduction*, and others) inherent to systematic knowledge, I will elucidate Helvétius' intention to confer the status of rigorous science to the moral domain, whose model would be newtonian experimental physics, and whose founding principle would be *physical sensibility*.

b) On the other hand, the aims of such a project cannot be separated from the rhetorical and non-systematic form in which it is exposed, thus troubling its pretense to scientificity. Indeed, despite the asserted intention of building the moral domain on deductive foundations, the skeptical standpoint endorsed by Helvétius leads him to assume a probabilistic notion of philosophical truth. This implies that no rigorous demonstration will ever be possible, the nature of a given truth being rather appreciable on a scale of degrees of greater or lesser probability. Thus, for Helvétius it is much more important *to persuade* rather than *to demonstratively convince* the reader of his truths.

On this hypothesis, it is also possible to provide a philosophical explanation of the diverse array of rhetorical expedients that Helvétius employs to enrich his argumentative style. Indeed anecdotes, allegories, fables and the like are needed in order *to visually present* the truth which, being in such a way *clearly expressed* and immediately graspable, can precisely persuade the reader of its *evidence* (another ambiguous category in Helvétius' thought), and obtain a quasi-demonstrative status.

A subtle and strong tension between the quasi-deductive foundations and their rhetorical expression is thus detectable at the heart of Helvétius' philosophy, a tension whose closer examination will contribute to strengthen the originality of his intellectual project.

Was There a "Late" Hegelian Philosophy?
System, Encyclopaedia, and Academic Research in Berlin

Antoine Auvé, Université Paris 1 Panthéon-Sorbonne

Hegelian philosophy still stands as the paradigmatic example of the conception of philosophy as a system: Hegel is often thought to have identified the completion of philosophy with the construction of a scientific system. Yet the mature form of Hegel's system is not, strictly speaking, a "system" but rather an *Encyclopaedia*, which evokes both eighteenth-century models and a research-oriented academic framework.

From the classical studies of K.-H. Volkmann-Schluck to the recent works of A. Arndt, commentators have argued (whether critically, or with the aim of reassessing Hegel's legacy) that there is, in fact, no Hegelian system. By developing his philosophy as an enterprise encompassing the totality of knowledge of his time, Hegel is thus said to have abandoned the very idea of a system.

However, this verdict presupposes a monolithic and unquestioned conception of systematicity. I argue that Hegel actually redefined (and did not implicitly abandon) this notion in connection with the institutional reorganization of knowledge within nineteenth-century German universities (thus also forming a Hegelian «school»).

Recent scholarship that has rediscovered in Hegel, above all, an epistemologist (for example, K.Westphal in the Anglo-American context, Ch. Halbig in Germany...), or even a precursor of the philosophy of science (E. Renault in France), makes it possible to rethink the idea of systematicity. Drawing on the invaluable materials contained in the *Gesammelte Werke* – i.e. the students' notebooks covering all parts of the *Encyclopaedia* – I will show that Hegel came to make historicity, and especially the historicity of knowledge (as demonstrated by Ch.-F. Lau in his work on the historicity of categories), an essential component of systematicity. Hegel thus appears not so much as the culmination of a metaphysical tradition, but rather as a forerunner of an interdisciplinary relation between philosophy and the sciences, in which empirical materials, constantly revised and reworked through his lectures, constitute an essential condition of the system itself.

Theoretical Philosophy

From Trascendental Constitution to Organized Complexity: On Kant's influence in Systems Theory

Rokas Vaičiulis, Vilnius University

This paper aims to consider the influence of the Kantian mode of philosophizing as the conceptual precedent to Systems Theory, or, broadly, systems thinking –as developed in divergent forms by the 20th century figures Ludwig von Bertalanffy, Niklas Luhmann and Francisco Varela–by investigating the relationship of self-determining knowing to the ontology of self-organization in systems thinking: the conceptual translation of the principles of knowledge in Kant to the modes of existence in systems thinking. The motivation of systematicity in Kant's theory of knowledge, as presented in the Critique of Pure Reason, can be found resonant with the approaches brought forth by systems thinkers Bertalanffy, Luhmann, or Varela. For Kant, the conditions of possibility of the knowing subject's cognitive capacities are specified through the systematization of cognition: transcendental reason demands the categories of the intellect to interact with the manifold of sensibility as a unitary structure in order to constitute the coherence of our experience. In other words, Kant's theory of knowledge is a theory of self-organization: the knowing subject both sets the boundaries of possible experience and the mode of knowing the experience. Systems thinking, likewise, is motivated by a recursive mode of thinking by inferring that the observing agent constitutes the system one describes, where the operational closure of the whole and its parts is formed. Yet, for systems thinkers, there is not a priori necessary mode of recursive system: systems are empirically contingent; the operational closure of the system is not rationally prescribed but rather arises from feedback loops and emergent patterns. For Bertalanffy, such is the case for the general systems in which the exchanges of matter, energy, and information occur; for Luhmann, the framework is applicable to notion of society, which is conceived not as a composition of individuals or actions but is rather differentiated as a manifold of communication systems; for Varela, the framework entails a theory of biology, whereby the notion of living organism is rendered as a self-producing entity. The thesis is the following: I propose to examine the notion of self-organization evinced in systems thinking (Bertalanffy, Luhmann, Varela)as based on the philosophical inheritance of the principles of Kantian transcendental philosophy. Three claims are implemented to support the thesis:(1) the conceptual relationship of the framework of Kant and the framework of systems theory is established through the comparison of theoretical principles:(a) between the conditions of possibility in Kant and boundary-formation in systems thinking, and (b)between the reflexive character of knowledge and the "second-orderliness" character in systems thinking; (2) the conceptual translation of the principles of knowledge in Kant to the accounts of self-organizing relational entities (biological, social and/or artificial) in systems theory is fulfilled through: (a) the reconceptualization of self-organization as the principle of knowledge in Kantto the principle of ontological relationship in systems theory; (b) the reconceptualization of self-organization from the principle of a priori necessity in Kant to the principle of contingency in systems theory; (3) in spite of the diversity of the accounts of systems thinking (Bertalanffy, Luhmann, Varela), the common conceptual ground among them is, I argue, precisely its indebtedness to the Kantian philosophical framework of specifying the conditions of possibility: Luhmann and Varela are both known to have explicitly engaged with Kant's ideas in their works.

A-centrism: Mathematics and Philosophies of Fluid Systems

Andrea de Donato, Università di Torino

In 1974, P. Rosenstiehl and J. Petitot proposed and developed the concept of «a-centric system» in their article Automate asocial et systèmes acentrés, in «Communications», 22 (1974), pp. 45-62, which was crucial for certain developments in contemporary French philosophy, in particular the notion of Rhizome by G. Deleuze and F. Guattari. This contribution aims to examine this proposal and compare it with certain contemporary epistemological positions between philosophy and mathematics, such as the compositional dynamics known as Differential Heterogenesis, introduced by the mathematicians A. Sarti, G. Citti and the semiotician D. Piotrowski. Starting from the notion of the a-centric system, which opposes the «military» hierarchies of the classical notion of system to a «fluid» systematisation, and essentially retracing the non-hierarchical theorems used by Rosenstiehl and Petitot (Erdos, Rényi and Sós's Friendship Theorem; Arrow's Collective Indecision Theorem), we will attempt to show in what terms this «conceptual metaphor» of a-centrism has an extra-mathematical, and therefore metaphysical and ontological, value. We will then briefly consider the distance it can take from certain unorthodox logics, quite apart from French debates, namely G. Priest's Dialetheism, H. Wansing's Dimathematism as well as fuzzy logics. Subsequently, once the epistemological status of a-centric systems has been determined, we will show how this has led to the proposal of a system in heterogenesis, or Differential Heterogenesis, i.e. the attempt to replace the very notion of a dynamical system with compositional dynamics which are subject to continuous variations in the logical norms that compose them. We will conclude: 1. a historical overview of French mathematical studies that oppose the notion of system; 2. a theoretical reconstruction of the transition from hierarchical systems to compositional dynamics; 3. an attempt to show how French anti-systemic proposals do not deny the notion of system at all, but rather reformulate it in an original way.

Systematicity without consistency

Cesare Cherchi, Univerzita Karlova

The traditional assumption in epistemology is that systematicity requires consistency. In classical models of knowledge, a system is expected to form a unified and contradiction-free whole, and the presence of conflicting commitments is usually taken to undermine its very structure (Hintikka 1962). This view has shaped how philosophers understand the relation between any kind of theory and their logical structure. Yet recent developments in logic and theory of knowledge now allow us to reconsider this assumption; we now have the conceptual and technical means to argue that consistency is not a necessary condition for a systematic body of knowledge. A first step in this direction appears in the idea that a system can be defined by its procedures of organisation rather than by the uniformity of its contents. A system may remain structured if it has methods for regulating and integrating cognitive commitments, even when these include semantic gaps or gluts (Rescher 1979). This procedural conception gains support from work on logics that permit inconsistency. These frameworks show that contradictions can be contained and made informative within controlled inferential environments, which means that the presence of conflict does not force a collapse of systematic order (Rescher and Bran-dom 1979).Technical developments in the study of computation reinforce this point by presenting models of rational processing that rely on non-classical mechanisms able to redistribute or tolerate contradictions without trivialising the system (Belnap 1977). And has recently been shown how such system can be made relevant interpreted doxastically, i.e. as consequence of a semantical structure that accounts for our cognitive architecture (Berto 2020); moreover, these structures seem to offer a natural interpretation for the syntax of many different kinds of paraconsistent logics (Priest 2006). This means allow for a greater flexibility in the description of any formalised theory and seem to get around many objections against structured knowledge (for in-stance the ones in Tarca 2014). Taken together, these developments shift systematicity away from the requirement of global coherence. They support a conception of knowledge systems that remain fruitful and productive even when they are not fully consistent.

From System to Ecosystem: Rethinking Co-Determination in Kitaro Nishida's Philosophy

Camille Hevré, Université Montpellier 3 Paul Valéry

This paper proposes a re-reading of Nishida Kitarō's notion of "system" not as a fixed, self-enclosed totality but as a dynamic movement of co-determination between acting and being-acted-upon. Against the modern tendency to conceive systems as self-grounded frameworks of knowledge that return to themselves, Nishida's philosophy invites us to think the "system" as a living process—an eco-systemin perpetual transformation. In his late writings, Nishida moves from a logic of substance to a logic of life, where each individual and its milieu mutually determine one another. Knowledge, therefore, cannot be reduced to the capture of an exterior by an interior; it emerges within a relational field where subject and object, self and world, continuously interpenetrate. Through this shift, Nishida's "dialectical world" opens a path beyond anthropocentrism: life is no longer a collection of isolated entities but an expressive web of interdependent relations, a poiesis of mutual transformation. By conceiving the system as a living totality that "forms itself self-expressively," Nishida offers a way to think of knowledge as ecological rather than epistemic—an event of co-creation rather than domination. His logic of contradictory self-identity thus provides a philosophical grounding for a non-dualistic understanding of systems: not structures of control, but dynamic unities where knowing and being, life and thought, act upon and through one another.

Education Sciences

T.E.H.E: an AI-integrated framework for a constructionist teaching approach

Lorenzo Natali, Università di Genova/ Itd Cnr

The development of 21st-century skillshas become a strategic priority for contemporary educational systems, with particular emphasis on fostering creativity, critical thinking, and digital literacy in order to prepare individuals to address today's complex challenges. From this perspective, it is crucial to adopt pedagogical approaches oriented toward skill development while meaningfully leveraging the potential of digital technologies.

This paper introduces a conceptual framework, T.E.H.E (Tool Engagement –Human Engagement), designed to integrate the pedagogically informed use of Generative Artificial Intelligence (Gen-AI) within an AI-driven constructionist pedagogy. The framework draws inspiration from Seymour Papert's constructionist paradigm and the Creative Problem Solving (CPS) model, seeking to align technological mediation with human-centered processes of creativity and reflection.

The T.E.H.E framework is structured around the alternation between phases of interaction with artificial intelligence (tool engagement) and moments of human reflection and re-elaboration (human engagement), corresponding to the three stages of the creative process outlined in CPS: understanding the problem, generating ideas, and planning for action. Within each phase, the pedagogically mediated use of AI tools—conceived as means of cognitive and generativeamplification—is alternated with reflective phases of human engagement aimed at developing creative, critical, and metacognitive competences.

This framework is intended to support learners in the co-construction of meaningful artefacts while promoting AI literacy and self-efficacy. By providing a guided creative workflow, the T.E.H.E framework seeks to mitigate challenges related to cognitive overload, AI dependency and overreliance, while safeguarding learners' agency and their role as active constructors of knowledge.

The proposal will be discussed from a theoretical standpoint by outlining relevant literature and the framework's structural and pedagogical features. An example of its application in a constructionist game design activity—an approach in which students engage in the design and creation of playful artefacts—will also be presented. Finally, the T.E.H.E framework is proposed as a foundation for future empirical research aimed at evaluating the impact of AI-integrated pedagogical approaches on learners' skills,self-efficacy, digital literacy, agency, and AI overreliance.

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Faculty Development and challenges of knowledge complexity: reflectivity as a 'systemic bridge' across and within the university teachers' competence frameworks

Arianna Marci, University of Genoa

In the current context of Higher Education, the growing complexity of knowledge and reality requires systemic approaches capable of overcoming the fragmentation of disciplinary fields. From this perspective, *Faculty Development* emerges as a strategic 'tool' for fostering transdisciplinary and interdisciplinary relations, supporting university teachers in developing the competences needed, also to design meaningful and transformative learning experiences. This contribution aims to explore how national and international reference frameworks conceptualize competences, skills, and tasks of university teachers, and how these can be related to those defining as well the roles and competences of *faculty developers* and *instructional designers*. Such relationships are essential for building coherent and systemic professional development pathways aligned with the evolution of knowledge, digital and technological transformation, etc., and their impact on educational processes. It is argued that pedagogical and didactic knowledge should not only functionally integrate with disciplinary knowledge but also engage in an authentic dialogue with it (e.g. philosophical, juridical, mathematical, engineering, medical, etc.). Only through such dialogue teaching can become effective and meaningful, capable of connecting epistemic diversity with students' learningful experiences. Furthermore, relating university teachers' competence frameworks to those expected of students —particularly regarding life and orientation competences —helps strengthen the systemic coherence of Higher Education and enhance the formative value of teaching itself. Finally, the contribution highlights the central role of reflectivity as the connective element among the different competence frameworks: reflective competence represents one of the most important and cohesive factor that enables the recognition, interpretation, and integration of complexity, transforming it into an opportunity for learning and the construction of meaning.

Keywords: faculty development; university teachers; competence frameworks; reflectivity; complexity

Informatics and Computational Thinking as a New Literacy for Complexity

Giulia Paludo, University of Trento

The 21st century landscape is posing several challenges to the envisaging of educational objectives: the rapid advancements and innovations make it difficult to keep the pace and previous approaches result to be not fully effective. Within this scenario, the possible transversal solution to address a global context defined by complexity, acceleration and deep interconnection, seems to be cultivating forms of thinking capable of navigating uncertainty and generating meaning across domains. On the other side the technology driven environment we are inserted in calls for a new, and less separatist, view on the connection between technical and humanistic disciplines.

Given these premises, informatics ad computational thinking can be understood not merely as technical abilities but as new cognitive literacies that reshape how individuals perceive, represent, and act upon the world. This is possible because they entail a symbolic system through which learners experience reasoning differently as well as cognitive and creative act. Informatics' learning, intended as information elaboration, and its means such as code become not only a matter of technical fluency but also of cultivating reflection, anticipation, and iterative reasoning skills that mirror complex, adaptive thought.

In fact, while learning to think computationally could raise the concern of steering thoughtful and creative processes in more mechanistic structures, on the other side, the prompt of informatics as literacy could not be less than an additional powerful tool future generations will employ to better navigate complexity.

More in detail, the characteristics of informatics, programming and computer science pose themselves as a combination of problem solving and literacy foreground its formative, ethical, and epistemological dimensions.

Knowledge and experience of informatics practices can then empower future citizens to engage with digital systems critically, creatively, and responsibly, rather than passively adapting to them.

Therefore, such perspective poses informatics and computational thinking within a systemic and transdisciplinary pedagogy to foster complex thinking, metacognitive awareness, and meaningful participation through active citizenship in digital and non-digital ecosystems.