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Towards a platform ecology: rethinking organisational models in the age of hyper-digitalisation

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Abstract

Hyper-digitalisation is profoundly transforming contemporary organisational models by redefining governance structures, value creation mechanisms and the dynamics of interaction between economic and institutional actors. Driven by the rise of technologies such as artificial intelligence, cloud computing, the Internet of Things and big data analytics, this transformation goes beyond the mere digitisation of processes to establish an organisational environment characterised by the constant interconnection of systems, data and actors. In this context, organisations operate in an environment marked by volatility, uncertainty, complexity and ambiguity, often described in the literature as VUCA.

At the heart of this transformation lie digital platforms, which can no longer be viewed as mere technical infrastructures facilitating transactions. They now constitute genuine socio-technical ecosystems within which users, developers, partner companies, technological infrastructures and regulatory frameworks interact. Recent literature on digital ecosystems highlights that these platforms operate according to principles similar to those of natural ecosystems, where value emerges from the dynamic interaction between different

interdependent actors (Parker, Van Alstyne & Choudary, 2016; Adner, 2017). From this perspective, the ecological metaphor allows us to understand platforms as complex adaptive systems, comparable to digital biomes hosting a diversity of interconnected actors and services.

This ecological analogy refers to the emerging concept of 'platform ecology', which draws on these elements, amplified by network effects and the intensive flow of data.

However, the rise of digital platforms is also accompanied by new forms of power asymmetry. The major global technology platforms – often referred to by the acronym GAFAM – concentrate a significant share of data governance and capture a large proportion of the value generated by interactions within their ecosystems. Research on 'platform capitalism' thus shows that platform operators can capture between 80% and 90% of the value produced by network effects, marginalising peripheral actors and reinforcing organisational dependencies (Srnicke, 2017; Zuboff, 2019). This concentration of digital power raises major issues regarding technological sovereignty, economic regulation and data governance.

Furthermore, hyper-digitalisation also generates significant environmental externalities. The rapid growth of digital

infrastructure – notably data centres and telecommunications networks – contributes to the increasing carbon footprint of the digital sector, which now accounts for a growing share of global greenhouse gas emissions. Estimates suggest that information and communication technologies could account for between 2% and 4% of global CO₂ emissions, with an upward trend linked to the expansion of digital services and data storage. These developments highlight the need to integrate the principles of digital frugality and environmental sustainability into the governance of digital platforms.

In this context, the central research question can be formulated as follows: how can traditional organisational models, often characterised by hierarchical and siloed structures, be rethought in order to adapt them to a hyper-digitalised environment dominated by digital platforms? The aim of this article is to propose a conceptual framework based on ‘platform ecology’ in order to better understand the organisational dynamics at work in contemporary digital ecosystems and to identify the conditions for the emergence of more resilient, collaborative and sustainable organisational models.

To address this issue, the study adopts a qualitative and interdisciplinary approach based on an in-depth literature review covering theories of digital platforms, the digital transformation of organisations, and systems ecology. This analysis is complemented by an examination of several illustrative cases drawn from the platform economy and digitalised higher education. The aim is not to produce an exhaustive empirical validation, but to propose a conceptual framework capable of shedding light on contemporary organisational transformations.

The results of this analysis highlight three fundamental principles underpinning a platform ecology. The first concerns the transition from hierarchical organisational structures to holararchical and modular architectures that promote team autonomy and decentralised innovation. The second relates to the establishment of adaptive forms of governance capable of regulating data use, ensuring algorithmic transparency and limiting technological dependencies. Finally, the third principle concerns the integration of a logic of regenerative sustainability, involving the reduction of the digital sector’s ecological footprint and the adoption of more responsible growth models.

In the Moroccan context, marked by the acceleration of national digital transformation strategies and the gradual widespread adoption of educational platforms in higher education, this reflection is of strategic importance. The growing integration of artificial intelligence and digital

learning environments in Moroccan universities raises fundamental questions regarding the governance of academic data, digital sovereignty and digital inclusion.

Ultimately, platform ecology offers an analytical perspective that allows us to move beyond a strictly technological view of digital transformation and to understand organisations as adaptive systems evolving within a globalised digital biotope. This approach thus opens up new avenues for rethinking organisational governance in the age of hyper-digitalisation, by linking technological innovation, social responsibility and ecological sustainability.

Keywords: Hyper-digitalisation; Platform Ecology; Educational Policies; Digital Transformation in Higher Education; Algorithmic Governance; Digital Sovereignty; Sustainable Digital Education.

1. Introduction

The digital transformation of education systems is now emerging as a key pillar of contemporary public policy. Under the combined influence of artificial intelligence, cloud computing, big data and global digital platforms, higher education is evolving towards hyperconnected environments characterised by intensified information flows and a restructuring of organisational frameworks (Yoo et al., 2012; Tilson et al., 2010). This dynamic, often described as ‘hyper-digitalisation’, goes beyond the mere digitisation of pedagogical processes: it reflects a systemic transformation of institutional models and governance frameworks.

Digital platforms, initially conceived as technological tools facilitating intermediation, now constitute genuine socio-technical ecosystems within which physical infrastructure, algorithms, user communities and legal regulations interact (Parker, Van Alstyne & Choudary, 2016). Value emerges from non-linear mechanisms amplified by network effects and the strategic exploitation of data. This evolution has profoundly transformed traditional value chains, fostering the emergence of new distributed and modular organisational forms (Adner, 2017).

However, this structuring into digital ecosystems is accompanied by significant tensions. Large global platforms concentrate algorithmic governance and capture a significant share of the value created, a phenomenon analysed in studies on platform capitalism (Srnicek, 2017). This concentration reinforces asymmetries in informational power and raises the question of the digital sovereignty of public institutions, particularly in the education sector (Zuboff, 2019). Furthermore, the rapid expansion of digital infrastructure

generates significant environmental externalities, with information technologies accounting for a growing share of global greenhouse gas emissions (Belkhir & Elmeligi, 2018).

In the field of education policy, these transformations call into question the ability of institutions to reconcile technological innovation, responsible regulation and ecological sustainability. The literature on complex adaptive systems highlights that organisations now operate in environments characterised by volatility, uncertainty and complexity (Holling, 1973), requiring flexible and resilient organisational architectures. However, the majority of digital transformation strategies remain focused on operational efficiency rather than a systemic approach integrating governance, ethics and sustainability.

It is against this backdrop that this article proposes the concept of ‘platform ecology’ as an analytical framework for rethinking educational organisational models in the era of hyper-digitalisation. Inspired by systems ecology (Odum, 1971) and business ecosystem theory (Moore, 1996), this approach views digital platforms as adaptive socio-technical biotopes where human actors, technological infrastructures and regulations co-evolve. It aims to move beyond an instrumental view of digital transformation to propose an organisational paradigm based on holarchy, adaptive governance and regenerative sustainability.

The article is organised into four main sections. The first part examines the theoretical foundations of hyper-digitalisation and platform ecosystems. The second presents the conceptual framework of platform ecology. The third analyses the implications for educational policies, particularly regarding digital sovereignty and algorithmic regulation. Finally, the fourth part discusses the conditions for the emergence of a resilient and sustainable educational model, using the Moroccan context as a strategic framework for reflection.

By linking systemic ecology, digital governance and educational transformation, this research aims to contribute to the theoretical renewal of organisational models in the era of hyper-digitalisation.

1.1. Hyperdigitalisation and the transformation of education policies

Digital transformation is now emerging as one of the most powerful drivers of the reconfiguration of education systems on a global scale (Selwyn, 2019; Castells, 2001). Far from being reduced to a mere instrumental modernisation, it entails a profound overhaul of the modes of production, transmission and legitimisation of knowledge. Whilst the first waves of

digitisation — theorised as early as the 1990s in the wake of the work of Negroponte (1995) and Lévy (1997) — were limited to transposing existing content and processes onto digital media without altering their underlying structures, the current phase is bringing about a transformation of an entirely different nature. A digitised library remains fundamentally a library; a dematerialised form remains fundamentally a form. Hyper-digitalisation, on the other hand, reconfigures practices, institutional roles and social interactions at their very core (Vial, 2019).

Vial (2019) defines digital transformation as a process through which digital technologies profoundly alter organisational models, social interactions and value creation mechanisms within organisations. Although formulated in a managerial context, this definition resonates particularly strongly in the field of education, where digital transformation is simultaneously reshaping curricula, assessment systems, pedagogical relationships and institutional structures. It is accompanied by a substantial redefinition of public higher education policies, which now incorporate digital technology not as an ancillary tool, but as a strategic, structuring pillar — through the promotion of e-learning, the deployment of digital work environments and the development of large-scale educational platforms (European Commission, 2021; UNESCO, 2023).

The concept of hyperdigitalisation emerges precisely at the intersection of several converging and interdependent transformations: the ubiquity of connected devices, the rise of generative artificial intelligence, the proliferation of big *data*, and the acceleration of technological innovation cycles (Schwab, 2016; van Dijck, Poell & de Waal, 2018). These transformations do not merely overlap with existing educational organisations: they permeate them, destabilise them and sometimes dissolve them, giving rise to new actors—MOOC platforms, EdTech companies, AI-based teaching assistants—which compete with, complement or supplant traditional institutions (Williamson, Bayne & Shay, 2020; Macgilchrist, 2019). This reconfiguration of the educational landscape is part of the broader dynamics of the platform economy (Parker, Van Alstyne & Choudary, 2016), which imposes new organisational models based on distributed collaboration, systemic interconnection and the intensive circulation of data.

Faced with this dynamic, education policies are gradually being forced to rethink their modes of governance to support the integration of digital technology whilst preserving the principles of equity, inclusion and data sovereignty (Williamson & Hogan, 2020; Selwyn, 2022). This governmental tension reveals an ambivalence inherent in

hyper-digitalisation, which Stiegler (2015) had anticipated by distinguishing between technology that enhances human capacities and that which supplants or even alienates them. Hyperdigitalisation carries this dual potential at its core: a lever for the emancipation and democratisation of knowledge on the one hand, and a vehicle for the standardisation, surveillance and commodification of education on the other (Zuboff, 2019; Morozov, 2013). This tension is neither accidental nor reducible to a technical implementation flaw; it is structurally constitutive of the phenomenon and must, as such, remain at the centre of any critical analysis of contemporary educational transformation.

1.2. From digitisation to hyper-digitisation

The digital transformation of education systems has unfolded along a historical trajectory that can be broadly broken down into two distinct phases, the qualitative break between which warrants precise theoretical analysis. The first phase – that of digitisation – corresponded to the introduction of isolated technological tools into learning environments: interactive whiteboards, digital tablets, connected classrooms, and learning management systems (*LMS*). This technological modernisation of educational infrastructure was primarily aimed at transferring pre-existing teaching practices to digital media, without questioning their epistemological foundations or organisational structures (Cuban, 2001; Selwyn, 2011). It was more a matter of substitution than transformation: the tools changed, but the underlying principles of action remained largely unchanged.

Recent literature agrees that the current phase goes well beyond this initial stage, entering a phase of hyper-digitalisation—a concept that refers to the systemic, cross-cutting and recursive integration of digital technologies across all organisational, educational and governmental processes (Yoo, Henfridsson & Lyytinen, 2010; Tilson, Lyytinen & Sørensen, 2010). This distinction is not merely quantitative — more technologies, more data — but fundamentally qualitative: whereas digitisation juxtaposes tools with existing organisations, hyperdigitalisation restructures these organisations from within, reconfiguring their coordination mechanisms, their modes of legitimation and their relationships to time and space (Orlikowski & Scott, 2008; Zuboff, 2019).

This transformation is largely explained by the intrinsic properties of contemporary digital technologies. Yoo et al. (2010, 2012) highlighted the *generative* capacity of digital infrastructures: unlike analogue technologies, digital technologies enable unprecedented functional recombination's, independently of their original designers.

This generativity fosters distributed innovation and the emergence of ecosystems in which diverse actors—educational institutions, technology companies, teachers, learners, content producers—interact to co-create value through unplanned configurations (Tilson et al., 2010; Nambisan et al., 2017). In this context, higher education institutions can no longer be analysed as closed, self-sufficient organisations, but must be understood as nodes within broader digital ecosystems, where the coordination of educational activities and the production of knowledge take place according to networked and distributed logics (Järvinen, 2016; Adner, 2017).

Hyper-digitalisation manifests itself concretely in the field of education through the integration of third- and fourth-generation technologies: *adaptive learning systems*, *learning analytics*, generative artificial intelligence, augmented and immersive reality, and digital twins of educational environments (Luckin et al., 2016; Williamson, 2017; Zawacki-Richter et al., 2019). These systems no longer merely support teaching practices; they are fundamentally reshaping them by introducing approaches based on the algorithmic personalisation of learning pathways, the systematic tracking of learners' behaviour, and the continuous optimisation of educational processes (Selwyn, 2019; Knox, 2020). Wider access to education, the individualisation of learning pathways and improved teaching quality are the central promises of this development — promises that proponents of a critical approach urge us to subject to rigorous and contextualised evaluation (Selwyn, 2016; Watters, 2021).

At the heart of this dynamic lies the concept of the digital platform. In economic and technological terms, a platform refers to an intermediary infrastructure that connects different types of users and creates value through their interactions, based on the logic of network effects and economies of scale (Parker, Van Alstyne & Choudary, 2016; Rochet & Tirole, 2003). Since the seminal work of Parker et al. (2016) on 'platform revolutions', we know that this model is based on a logic of orchestration rather than direct production: the platform does not teach, nor does it produce knowledge—it structures the conditions under which other actors teach, learn and produce knowledge. Applied to the field of education, this model raises fundamental questions that the critical literature is only just beginning to formalise (Perrotta & Williamson, 2018; Macgilchrist, 2019). Educational platforms—whether Moodle, Google Classroom, Coursera, or the digital work environments deployed in institutions—are not neutral and transparent tools. They incorporate implicit pedagogical assumptions, biased data architectures, and economic logics that structure—often invisibly—teaching and learning practices (Facer, 2011; Williamson, Bayne & Shay, 2020).

The concept of a digital educational ecosystem, borrowed from biology by way of a productive analogy, helps to capture the complexity of these interdependencies (Moore, 1993; Iansiti & Levien, 2004). Such an ecosystem encompasses not only the platforms themselves, but also the full range of human and institutional actors that inhabit and constitute them: teachers, learners, administrators, content producers, assessors, regulators, private investors. It also incorporates the multiple forms of regulation—public, market-based and professional—that structure its functioning and guide its evolution (van Dijck, Poell & de Waal, 2018; Gorur, 2019). Viewing hyper-digitalised education systems as ecosystems means recognising their irreducibly complex, dynamic and co-evolutionary nature — and, consequently, the inadequacy of linear and deterministic analytical frameworks to account for them (Morin, 1990; Stacey, 1996).

1.3. Digital platforms and educational ecosystems

The rise of digital platforms is one of the most defining phenomena of contemporary digital transformation, to the extent that some authors speak of a veritable ‘platform revolution’ to describe the organisational and economic shift they have brought about (Parker, Van Alstyne & Choudary, 2016; Kenney & Zysman, 2016). In the economic and technological sense of the term, a platform refers to an intermediary infrastructure that facilitates interactions between different groups of users within a market or digital ecosystem, creating value not through the direct production of goods or services, but through the orchestration of exchanges between complementary actors (Rochet & Tirole, 2003; Evans & Schmalensee, 2016). This model is fundamentally based on network effects—both direct and indirect—whereby the value of a service grows exponentially with the number of users participating in it (Katz & Shapiro, 1985; Parker et al., 2016). This logic profoundly transforms traditional value creation mechanisms by fostering the emergence of multi-sided markets in which producers, consumers and third-party developers coexist and interact within the same ecosystem (Eisenmann, Parker & Van Alstyne, 2006).

When applied to the field of education, this platform model raises fundamental questions that go far beyond the realm of mere technological efficiency. Educational platforms — whether Moodle, Google Classroom, Coursera, edX, or digital learning environments (*DLEs*) deployed in schools — are not neutral, transparent tools serving pre-established educational goals. They incorporate implicit pedagogical assumptions, oriented data architectures and economic logics that structure, often invisibly, teaching and learning practices (Facer, 2011; Williamson, 2017; Perrotta & Williamson, 2018). In this sense, any educational platform is simultaneously a technical,

pedagogical and political device — in the sense that it embodies normative choices regarding what education should be, how it should be organised and who should benefit from it (Selwyn, 2019; Macgilchrist, 2019).

This political dimension of educational platforms is particularly evident in national contexts where their roll-out forms part of state modernisation strategies. In Morocco, the **Massar** platform — an integrated digital school management system — is a prime example of this trend towards the platformisation of educational administration: it enables the digital management of the educational pathways of millions of pupils and facilitates interconnection between educational institutions and public services, whilst centralising massive data flows on the system’s stakeholders (Ministry of National Education, 2015; Benali & Zaid, 2020). At the international level, initiatives led by UNESCO, UNICEF and the World Bank aim to promote the development of open educational resources and interoperable digital platforms, with a view to broadening access to education — particularly in the Global South (UNESCO, 2019; World Bank, 2020). These initiatives, however laudable their intentions may be, are not immune to the tensions inherent in any platformisation strategy: between standardisation and contextualisation, between accessibility and technological dependence, between openness and data control.

To capture the complexity of these interdependencies, the concept of the digital educational ecosystem emerges as a particularly fruitful analytical framework. Borrowed from biology through a productive analogy (Moore, 1993; Iansiti & Levien, 2004), the ecosystemic metaphor allows us to move beyond an instrumentalist conception of platforms and to understand them as living, dynamic and co-evolving environments. A digital educational ecosystem is not limited to its technological components: it encompasses all the human and institutional actors who inhabit and constitute it — teachers, learners, administrators, content producers, assessors, public regulators, private investors — as well as the multiple forms of regulation that structure its functioning (van Dijck, Poell & de Waal, 2018; Gorur, 2019). From this perspective, educational platforms can be analysed as **socio-technical ecosystems** (Bijker, Hughes & Pinch, 1987; Orlikowski & Scott, 2008), within which value creation results not solely from the performance of algorithms, but from the dynamic and often conflictual interaction between technologies, institutions, professional standards and learning communities.

This ecosystemic conception leads to a reformulation of the question of the governance of educational platforms. In an ecosystem, there is no single centre of control: regulation

takes place in a distributed manner, through mechanisms of self-organisation, negotiation and mutual adjustment between actors with partially divergent interests (Stacey, 1996; Adner, 2017). Higher education institutions, government departments, EdTech companies and teaching communities do not participate in these ecosystems with the same resources, the same capacity for influence or the same time horizons. Analysing power relations within these ecosystems is therefore a key analytical and political challenge, which the critical literature on educational platforms is only just beginning to formalise systematically (Williamson & Hogan, 2020; Selwyn, 2022; Watters, 2021).

1.4. Education policy and digital governance

The integration of digital technologies into education systems is not merely a technical challenge of equipment and connectivity: it entails a profound transformation of the modes of governance, regulation and legitimisation of public education policies (Williamson, 2017; Ball, 2012). Education authorities are indeed faced with the need to reconcile structurally conflicting objectives: promoting technological innovation and the efficiency of systems, ensuring equitable access and digital inclusion, protecting learners' personal data, and preserving the autonomy of educational institutions in the face of the growing power of private digital sector actors (Selwyn, 2016; Williamson & Hogan, 2020). This multiplicity of potentially contradictory objectives reveals that the digital governance of education is not a technical problem to be solved, but a political problem to be negotiated — that is to say, a space for conflict, compromise and trade-offs between actors with divergent interests (Lascoumes & Le Galès, 2007; Ball, 2016).

At the heart of this issue lies the question of the governance of educational data, which has become one of the major strategic challenges facing hyper-digitalised education systems. Digital platforms deployed in educational settings collect, process and analyse vast amounts of data relating to learning activities, academic performance, learner behaviour and user interactions (Williamson, 2017; Selwyn, 2019). This datafication of education—that is, the transformation of complex educational phenomena into quantifiable and analysable data—raises fundamental issues regarding privacy protection, algorithmic transparency, informed consent and digital sovereignty (Mayer-Schönberger & Cukier, 2013; Lupton & Williamson, 2017; Regan & Jesse, 2019). Research on the governance of platform ecosystems highlights that data management is a key element in the sustainability and legitimacy of these systems: educational organisations must establish governance mechanisms capable of ensuring a balance between the use of data for educational innovation and

the effective protection of users' rights (Taddeo & Floridi, 2016; Prinsloo & Slade, 2017).

The governance of education systems in the digital age is characterised by a structural tension between two logics which, following Carnoy and Rhoten (2002), can be described as the logic of sovereignty and the logic of integration. On the one hand, states seek to maintain their educational sovereignty — understood as the capacity to define the aims, content and methods of national education — in the face of the growing power of private digital actors whose platforms effectively shape learning environments (Robertson & Dale, 2015; Verger, Fontdevila & Zancajo, 2016). On the other hand, the imperatives of modernisation, efficiency and international appeal in a context of global educational competition are pushing these same states to integrate technological solutions developed by these private actors, even if it means ceding an increasing share of the regulation of educational processes to them (Hogan, 2016; Bradbury, 2019). This tension cannot be resolved: it is managed, always provisionally, through institutional configurations, a comparative analysis of which reveals the diversity of possible arrangements.

A comparative analysis of major national digital plans for education clearly illustrates this tension. Whether it be the French Digital Plan for Education (2015), the European *Digital Education Action Plan* (2021–2027), the UK's *Realising the Potential of Technology in Education* strategy (2019), or Morocco's Strategic Vision 2015–2030 and Framework Law 51-17, these strategic documents reveal a dual ambition: to equip education systems with robust digital infrastructure whilst preserving the guiding principles that underpin their democratic legitimacy — equity, universality and quality (European Commission, 2021; Ministry of National Education, Morocco, 2019). Reconciling these objectives constitutes one of the most complex challenges of contemporary educational governance, particularly as public-private partnerships, which have become indispensable in the development of digital educational infrastructure, introduce market-based accountability frameworks that do not always align with public service principles (Ball & Youdell, 2008; Hogan, Sellar & Lingard, 2016). In Morocco, national digital transformation strategies — centred on the Massar and Telmid TICE platforms — illustrate precisely this complexity: caught between ambitions for modernisation and structural constraints of unequal access between urban and rural areas, and between developed regions and isolated areas (Benali & Zaid, 2020; CSEFRS, 2019).

Contemporary education systems increasingly rely on data-driven governance mechanisms, enabling authorities to monitor school performance in real time and to guide public

policy using digital indicators (Ozga, 2009; Williamson, 2016). This shift towards *evidence-based policy* is accompanied by a profound transformation of the instruments of public educational policy: indicator dashboards, integrated information systems and institutional analytics tools are becoming the new benchmarks for educational decision-making (Lingard, Martino & Rezai-Rashti, 2013; Lawn, 2013). This digital instrumentation of governance is not neutral: it prioritises certain dimensions of educational activity — those that are quantifiable and comparable — at the expense of others, which are less visible but just as essential, such as the development of critical thinking, socialisation or personal fulfilment (Biesta, 2010; Ravitch, 2010).

It is in this context that the concept of algorithmic governance, theorised by Rouvroy and Berns (2013) within the broader framework of ‘algorithmic governmentality’, provides particularly illuminating insights. Educational decisions—student guidance, identifying school dropouts, teacher evaluation, resource allocation—are increasingly informed, and sometimes superseded, by automated data analysis systems that operate according to opaque logic, which is difficult for educational stakeholders themselves to audit (Rouvroy & Berns, 2013; Gillborn, Warmington & Demack, 2018). This algorithmisation of educational governance raises fundamental ethical and democratic questions: who controls the algorithms that shape educational outcomes? According to what criteria do adaptive learning systems personalise learners’ pathways? What forms of recourse are available to educational stakeholders in the face of algorithmic decisions? (O’Neil, 2016; Dencik et al., 2019). These questions cannot be sidestepped in any serious reflection on the digital transformation of education systems, lest we confuse technological modernisation with democratic progress.

2. Conceptual framework: platform ecology

In order to grasp the full complexity of the organisational transformations brought about by the hyper-digitalisation of education systems, this article proposes to draw on an original conceptual framework: the ecology of platforms. This framework is not a convenient metaphor borrowed from the natural sciences, but a genuine analytical framework built upon the rigorous articulation of several complementary theoretical traditions — ecological thought, complex systems theory, platform economics and the critical sociology of digital organisations. Its aim is to transcend the limitations of reductionist approaches to offer a systemic, relational and critical interpretation of contemporary educational transformations (Morin, 1990; Stacey, 1996; Zuboff, 2019).

The transposition of the ecological concept to the organisational field has a long intellectual history that warrants a brief review to appreciate its fruitfulness. As early as the 1970s, Hannan and Freeman (1977) introduced the ecology of organisational populations to analyse the dynamics of selection and adaptation of organisations in competitive environments. In the field of educational sciences, it was Bronfenbrenner (1979) who laid the foundations for a bioecological approach to human development, conceptualising the learning environment as a system of nested systems—microsystem, mesosystem, exosystem, macrosystem—whose interactions shape the individual’s development. Whilst this model remains centred on individual development, it provides a valuable structural framework for understanding the complexity of contemporary digital educational environments (Tudge et al., 2009; Neal & Neal, 2013). The theory of complex systems, as developed by Morin (1990) in his project on ‘complex thought’ and by Stacey (1996) in his work on organisational dynamics, provides a second essential theoretical foundation: organisations, like biological ecosystems, are complex adaptive systems characterised by non-linearity, emergence, self-organisation and sensitivity to initial conditions (Holland, 1995; Axelrod & Cohen, 1999). Within this framework, organisational behaviours cannot be deduced from the simple aggregation of individual behaviours: they emerge from interactions between actors, technologies and institutional structures according to patterns that no central planning can fully anticipate or control (Snowden & Boone, 2007). The seminal works of systems ecology — notably those of Odum (1971) on ecosystem metabolism and Holling (1973, 1986) on resilience and adaptive cycles — provide a third theoretical foundation of the highest order. Holling conceptualised the *adaptive* cycle as a universal model of complex systems dynamics, alternating between phases of rapid growth, conservation, creative release and reorganisation. This model allows us to analyse the transformations brought about by hyper-digitalisation not as a linear and irreversible rupture, but as a cyclical process of destabilisation and reconfiguration, in which crises — such as that of Covid-19 — act as liberating disruptions opening windows of opportunity for organisational innovation (Gunderson & Holling, 2002; Uhl-Bien & Marion, 2009).

Building on these theoretical foundations, the framework of platform ecology views digital educational platforms as complex socio-technical ecosystems (Bijker, Hughes & Pinch, 1987; Orlikowski & Scott, 2008) within which two broad categories of components interact. On the one hand, abiotic factors — in the sense of systems ecology (Odum, 1971) — correspond to the technological and institutional infrastructures that structure the digital environment: IT infrastructures, algorithms, data architectures, interoperability

protocols, regulatory frameworks and standardisation norms. These elements constitute the technical and institutional substrate upon which platforms rest and determine their capacity to support interactions between actors. On the other hand, **biotic actors** represent the human and organisational participants who interact within the ecosystem: users, developers, partner companies, educational institutions, public regulators, investors and private. In the context of higher education, these actors include students, teachers, researchers, administrative staff and academic institutions, who collectively participate in the production, circulation and valorisation of knowledge through platforms (Parker, Van Alstyne & Choudary, 2016; Adner, 2017). The dynamic interaction between these two dimensions generates flows of data and information that constitute the central driver of value creation in digital ecosystems: organisational value is no longer produced by a centralised, integrated organisation, but emerges from distributed interactions between the various actors in the ecosystem — what Parker et al. (2016) refer to as the shift from a pipeline logic to a platform logic. This logic of orchestration rather than direct production endows platforms with remarkable generative capacity (Yoo et al., 2010), but also with a lack of transparency and power asymmetry that critical literature has gradually brought to light (Zuboff, 2019; van Dijck, Poell & de Waal, 2018).

The framework of platform ecology is based on five fundamental principles, the articulation of which constitutes its analytical coherence. The first is the principle of interdependence: the actors, mechanisms and institutions that make up a digital educational ecosystem are linked by bonds of mutual and recursive dependence, such that any change to one element produces cascading effects across the entire system (Weick, 1979; Perrow, 1984), thereby rendering segmented and sectoral approaches to governance structurally unsuitable. The second is the principle of co-evolution: educational organisations and digital platforms evolve jointly within a dialectical and non-linear dynamic (Lewin & Volberda, 1999; Dosi & Nelson, 1994), which means that there is no neutral technology that can be uniformly applied to pre-existing organisations: platforms reconfigure the organisations that adopt them, whilst organisations resist, subvert and reappropriate platforms according to their own logic (Orlikowski, 1992; de Certeau, 1990). The third principle concerns ecological niches: just as in biology, the various actors within a digital educational ecosystem occupy specific niches defined by their resources, distinctive skills and adaptation strategies (Hannan & Freeman, 1977; Baum & Singh, 1994) — research-intensive universities, distance learning institutions, MOOC platforms, EdTech companies and vocational training organisations entering into relationships that are at times competitive, at times symbiotic,

and at times commensal. The fourth principle is that of **resilience**: the capacity of an educational ecosystem to absorb shocks, adapt to disruptions and maintain its essential functions whilst undergoing transformation (Holling, 1973; Walker et al., 2004) — a dimension that the Covid-19 health crisis has put to the test on a massive scale, simultaneously revealing unsuspected resources and deep-seated structural weaknesses (Pokhrel & Chhetri, 2021; UNESCO, 2020). Finally, the fifth principle is that of distributed governance: in a complex ecosystem, there is no single centre of control capable of steering the entire system through a command-and-control approach (Ostrom, 1990; Ansell & Gash, 2008); regulation takes place through mechanisms of self-organisation, negotiation and mutual adjustment between actors with partially divergent resources and interests, which calls for a fundamental rethinking of traditional conceptions of educational governance based on hierarchy and centralised prescription.

Based on these five principles, the framework identifies three structuring organisational pillars, the interrelationships of which are illustrated by the conceptual model presented in Figure 1. The first pillar is organisational holarchy — a concept borrowed from Koestler (1967) and updated by Robertson (2015) in his theory of holacracy — which refers to modular structures characterised by distributed team autonomy, mechanisms for co-creating value, and a capacity for rapid adaptation to VUCA (*Volatility, Uncertainty, Complexity, Ambiguity*) (Bennett & Lemoine, 2014; Johansen, 2012). The second pillar is adaptive governance, a concept developed in work on the management of common-pool resources (Ostrom, 1990; Folke et al., 2005), which is based on algorithmic transparency, multi-level regulation and digital sovereignty, enabling the risks of technological dependence on major global platforms to be limited whilst preserving local innovation capacities (Zuboff, 2019; Dencik et al., 2019). The third pillar is that of regenerative sustainability, which integrates the dimensions of digital frugality, the circular economy of digital resources and the reduction of the carbon footprint of infrastructure into organisational strategies — dimensions long neglected in discussions on digital transformation (Freitag et al., 2021; Shift Project, 2019).

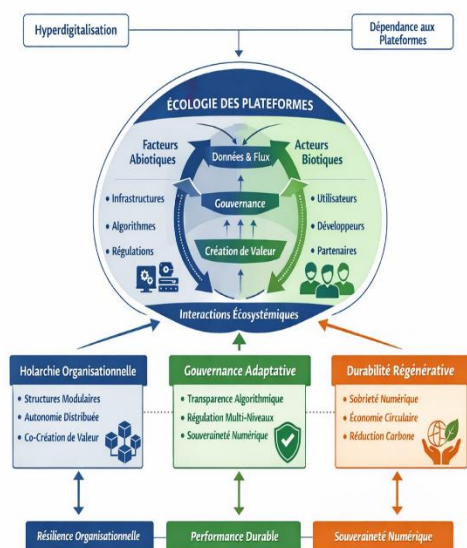


Figure1: Conceptual model of platform ecology in digital educational ecosystems

Figure 1 provides a concise and structured representation of this conceptual framework; an analytical examination of it allows for a deeper understanding of its internal coherence. The model is organised according to a three-tiered architecture. The top level situates the framework within its macro-environmental context by identifying the two driving forces affecting contemporary educational organisations: hyper-digitalisation on the one hand, and platform dependency on the other. This dual pressure indicates that the digital transformation of organisations does not take place in a space of unlimited freedom, but under the constraint of powerful structural logics that guide and sometimes capture organisational trajectories (Zuboff, 2019; van Dijck, Poell & de Waal, 2018). Dependence on platforms — a phenomenon referred to in the economic literature as ‘*platform lock-in*’ (Gawer & Cusumano, 2014) — constitutes a particular systemic risk for public educational institutions, whose decision-making autonomy may be gradually eroded by their growing dependence on digital infrastructures controlled by private actors. The intermediate level, at the heart of the model, represents the platform ecosystem as a dynamic ellipse organised around four elements in circular interaction: abiotic factors, biotic actors, data and flows, and governance — with value creation at its centre as the result of all ecosystem interactions. The circular arrow linking these four components illustrates the dynamics of co-evolution and mutual interdependence, whilst the central position of governance highlights its role as an arbiter of the tensions inherent in any complex ecosystem (Ostrom, 1990; Folke et al., 2005). The lower level of the model breaks down the organisational implications into three pillars connected to ecosystem

interactions by bidirectional arrows, signalling their dual nature as both constituting and constituted. The organisational holarchy structurally reflects the shift from a command-and-control approach to one of orchestration and self-organisation, implying a profound reconfiguration of institutional roles (Senge, 1990; Uhl-Bien & Marion, 2009). Adaptive governance directly addresses the risks identified at the highest level of the model: in the face of platform dependency, it constitutes the regulatory mechanism that enables educational organisations to preserve their decision-making autonomy, with algorithmic transparency acquiring particular strategic importance in environments where educational decisions are increasingly informed by automated data analysis systems (Rouvroy & Berns, 2013; O’Neil, 2016). Regenerative sustainability, finally, serves as a reminder that any ecological approach must incorporate the issue of resource regeneration, lest the system be depleted. The three organisational outcomes positioned at the bottom of the model—organisational resilience, sustainable performance and digital sovereignty—constitute the objectives targeted by the articulation of these three pillars. Their bidirectional connection with the pillars emphasises that these outcomes are not guaranteed mechanical effects, but dynamic equilibria that must be continually maintained, in line with the logic of Holling’s adaptive cycle (1973): resilience, performance and sovereignty must be perpetually rebuilt through processes of organisational learning, institutional adjustment and negotiation between actors (Gunderson & Holling, 2002; Weick & Sutcliffe, 2007).

From an epistemological perspective, the framework of platform ecology deliberately positions itself between two symmetrical pitfalls. The first is techno-determinism — widespread in managerial and political discourse on digital transformation — which reduces organisational transformations to mechanical and inevitable effects of technological developments, thereby depriving actors of all agency and organisations of any capacity for resistance or reappropriation (Winner, 1980; Ellul, 1977). The second is radical social constructivism, which would deny the inherent materiality of technologies and their capacity to structure social interactions independently of the intentions of the actors (Latour, 2005; Orlikowski & Scott, 2008). Platform ecology proposes a middle ground, rooted in the sociomateriality tradition (Orlikowski & Scott, 2008) and actor-network theory (Latour, 2005; Callon, 1986): technologies and human actors are mutually constitutive, and their interactions produce organisational configurations that cannot be reduced to either a purely technological or a purely social logic. This perspective ultimately calls for us not to exonerate educational platforms from their power effects: following the concept of surveillance capitalism developed by Zuboff (2019) and

research on the *platformisation* of the media (Nieborg & Poell, 2018), platforms collect, process and monetise behavioural data that constitute a major economic resource. A truly critical platform ecology cannot overlook this analysis of the power relations and accumulation logics that permeate digital educational ecosystems — lest it be reduced to a theory of modernisation which, under the guise of systemic complexity, would reproduce the blind spots of the approaches it claims to transcend.

3. Implications for educational organisational models

3.1. From hierarchical organisation to adaptive organisation

The organisational models that dominated the field of education during the 20th century bear the deep imprint of two converging intellectual legacies: the principles of the scientific organisation of work as formalised by Taylor (1911), and Weberian bureaucratic rationality as theorised by Weber (1922). The division of tasks, disciplinary specialisation, hierarchical roles, standardisation of procedures and centralisation of decision-making formed the pillars of an organisational model that proved undeniably effective in a context of environmental stability and linear growth (Mintzberg, 1979; Scott, 2003). Schools, universities and all educational institutions have been profoundly shaped by this bureaucratic logic, to the extent that some authors refer to a ‘school grammar’ to describe the remarkable resistance of these structures to any attempt at fundamental transformation (Tyack & Cuban, 1995; Cuban, 2013). This model is now coming into increasing and potentially irreconcilable conflict with the demands of a hyper-digitalised environment, characterised by volatility, uncertainty, complexity and ambiguity — what strategic management theorists refer to by the acronym VUCA (*Volatility, Uncertainty, Complexity, Ambiguity*) (Bennett & Lemoine, 2014; Johansen, 2012). In a VUCA environment, rigid hierarchical structures, based on centralised decision-making chains and long planning cycles, lose their adaptive advantage to more flexible, responsive and distributed organisational configurations (Eisenhardt, 1989; Brown & Eisenhardt, 1998).

The emergence of digital platforms challenges these traditional organisational models in a particularly direct way. In digital ecosystems, value creation relies more on collaboration between interdependent actors than on the vertical coordination of activities (Parker, Van Alstyne & Choudary, 2016; Adner, 2017). Educational institutions thus find themselves embedded in complex networks of interdependence with external actors—technology companies, edtech start-ups, online learning communities,

open content producers—whose logic and timelines they do not control (Williamson, 2017; Hogan, 2016). This restructuring of the educational organisational environment requires a fundamental review of internal structures, roles and coordination methods, lest there be a gradual disconnect between educational organisations and the digital ecosystems that surround and permeate them (Christensen, Horn & Johnson, 2011; Selwyn, 2019).

It is in this context that the adaptive organisation emerges as an alternative model of reference. As it emerges from the seminal works of Senge (1990) on the learning organisation, Weick (1995) on organisational sense-making, Nonaka and Takeuchi (1995) on knowledge creation in organisations, and Heifetz and Linsky (2002) on adaptive leadership, the adaptive organisation is defined not as a fixed and stable structure, but as a dynamic process of constant adjustment to changes in the environment. It is based on four fundamental capabilities: the capacity for *double-loop learning*, which enables organisations to question not only their practices but also the underlying assumptions (Argyris & Schön, 1978); the capacity for collective *sense-making*, which enables members of the organisation to construct shared representations of ambiguous environments (Weick, 1995); the capacity for organisational ambidexterity, which enables the organisation to combine the exploitation of existing assets with the exploration of innovation (March, 1991; Tushman & O'Reilly, 1996); and the capacity for resilience, which enables an organisation to absorb shocks and transform itself without losing its fundamental identity (Holling, 1973; Weick & Sutcliffe, 2007).

Applied to the educational context, this shift from a hierarchical organisation to an adaptive organisation entails at least four concrete and interdependent transformations. The first concerns educational leadership. The headteacher or head of training ceases to be a mere manager of procedures and compliance to become an orchestrator of innovation, a facilitator of organisational learning and a mediator of the tensions inherent in transformation (Spillane, 2006; Fullan, 2001). This shift from transactional leadership to transformational leadership — or even adaptive leadership in the sense of Heifetz and Linsky (2002) — requires new skills: the ability to mobilise coalitions of diverse stakeholders, the capacity to maintain a strategic vision amidst uncertainty, and an understanding of the political and institutional dynamics that permeate any educational organisation (Day et al., 2016; Leithwood et al., 2020). The second transformation concerns the structure of teaching teams: working groups tend to organise themselves in a more cross-cutting and multidisciplinary manner, in response to complex issues that transcend traditional disciplinary boundaries (Hargreaves &

Fullan, 2012; Little, 2003). *Professional Learning Communities*, flexible project teams and *co-design teams* constitute the emerging organisational forms of this new structuring of educational work (DuFour & Eaker, 1998; Stoll et al., 2006).

The third transformation concerns the redefinition of forms of authority within educational organisations. The traditional hierarchical model concentrated authority in formal institutional positions; the adaptive model distributes it across different registers of legitimacy — hierarchical authority based on institutional control, functional authority focused on team leadership and the coordination of pedagogical initiatives, and expert- al authority based on mastery of professional knowledge and practices (Mintzberg, 1979; Spillane, Reiser & Reimer, 2002). This distribution of authority does not eliminate organisational tensions—it shifts and reconfigures them—but it creates the conditions for more distributed pedagogical innovation and more collaborative and responsive learning environments (Hargreaves & Shirley, 2009; Robinson, Lloyd & Rowe, 2008). Finally, the fourth transformation concerns assessment and accountability. Traditional quantitative indicators—success rates, progression rates, employment rates—are proving structurally inadequate to capture the richness and complexity of learning in a digital environment (Biesta, 2010; Ravitch, 2010). New approaches are emerging, based on *learning analytics*, the analysis of digital engagement data, skills portfolios and qualitative metrics that seek to capture previously invisible dimensions of the educational process—creativity, collaboration, critical thinking, metacognition (Boud & Falchikov, 2006; Luckin et al., 2016; Williamson, Bayne & Shay, 2020). This shift towards multidimensional and contextualised assessment constitutes one of the most profound — and most contested — transformations brought about by the hyper-digitalisation of education systems, insofar as it directly affects the mechanisms of legitimation and social selection that lie at the heart of the school's institutional function (Bourdieu & Passeron, 1970; Gillborn, Warmington & Demack, 2018).

3.2. Application to the Moroccan context

Morocco provides a particularly instructive case study for analysing the tensions between inherited organisational models and the imperatives of digital transformation, precisely because it brings together, in a unique configuration, dynamics found to varying degrees across all education systems in the Global South: strong administrative centralisation, deep territorial inequalities, a demographic transition placing pressure on education systems, and an ambition for accelerated modernisation driven by national and

international strategic commitments (World Bank, 2018; OECD, 2017; Kingdom of Morocco, 2019). Digital transformation is established there as a cross-cutting strategic priority, at the intersection of education policies, economic development strategies and ambitions to position the country within the global knowledge economy (CSEFRS, 2019; Ministry of the Digital Economy, 2021).

The Moroccan education system bears the hallmarks of administrative centralisation inherited both from a post-colonial nation-building project — in which schools played a central role in linguistic, cultural and identity unification (Vermeren, 2002; Benali, 2010)—and the influence of the structural reforms of the 1980s and 1990s, carried out under the auspices of the Bretton Woods institutions and characterised by a drive towards standardisation and accountability (Hibou, 2011; Belfkih, 2000). This centralisation, which for a long time served as a lever for national unification and curriculum standardisation, is now being put to the test by the demands of a hyper-digitalised environment that calls, on the contrary, for flexibility, differentiation and distributed governance (Alami, Zaid & Radid, 2020; Benali & Zaid, 2020). This structural tension between a centralising legacy and the imperatives of adaptive transformational re s the guiding thread of any serious analysis of Moroccan educational reform in the digital age.

The founding strategic documents of Moroccan educational reform reflect the official ambition to overcome this tension. The Strategic Vision for Reform 2015–2030, drawn up by the Higher Council for Education, Training and Scientific Research (CSEFRS, 2015), and Framework Law 51-17, adopted in 2019, jointly enshrine the importance of digital technology as a lever for systemic transformation of the education system. These texts set out the ambition for the Moroccan education system to equip citizens with the digital skills necessary for active participation in the knowledge economy, whilst upholding the values of equity, inclusion and democratic citizenship (CSEFRS, 2019; MEN, 2019). In particular, they provide for the widespread adoption of digital working environments, the development of digital teaching resources adapted to the local context, and the strengthening of connectivity infrastructure across all schools and universities nationwide. These ambitions build on several previous national programmes — the 2013 Digital Morocco Plan, the GENIE programme (*Generalisation of Information and Communication Technologies in Education*), launched in 2006, and the INJAZ programme — which constituted the first structured attempts to integrate digital technology into Moroccan education (Kettani & Moulin, 2014; Karsenti & Collin, 2013).

The assessment of these initiatives, which is well documented in the specialist literature, is nuanced and offers valuable insights for the theory of educational organisational transformation. The GENIE programme illustrates with particular clarity the limitations of an approach to digital transformation that is reduced to technological equipment: whilst this programme has enabled a significant number of schools to be equipped with IT hardware and interactive whiteboards, impact studies have shown that the availability of equipment was not sufficient to transform teaching practices in the absence of appropriate teacher training, curriculum revision and organisational support at school level (Berrada & Burgos, 2021; Alami et al., 2020; UNESCO-BREDA, 2012). This finding is consistent with the conclusions of international comparative literature, which consistently highlights the inadequacy of technology-centred approaches to educational transformation and the need to invest simultaneously in infrastructure, skills, professional cultures and organisational structures (Cuban, 2001; Fullan, 2007; Selwyn, 2011).

The **Massar** platform — an integrated digital management system for educational pathways rolled out from 2012 — is, for its part, a prime example of the potential and limitations of the platformisation of Moroccan educational administration (MEN, 2015; Benali & Zaid, 2020). By enabling the centralised management of data on millions of pupils — enrolments, assessments, absences, guidance — and by facilitating interconnection between educational institutions and public services, Massar represented a significant step forward in administrative modernisation. It nevertheless raises important questions from the perspective of the analytical framework of platform ecology: questions of sovereignty over educational data, transparency of guidance algorithms, interoperability with other digital systems, and above all the governance of an infrastructure on which the entire national education system now depends (Alami et al., 2020; Rouvroy & Berns, 2013). The more recent development of the Telmid TICE platform, dedicated to digital teaching resources, demonstrates a desire to complement the administrative infrastructure with an educational one, even though the rate of adoption and actual use by teachers remains uneven across regions and levels of education (Berrada & Burgos, 2021).

From March 2020 onwards, the **Covid-19 pandemic** constituted a decisive and revealing test for these ambitions of digital transformation. The sudden closure of schools forced the Moroccan education system to switch urgently to distance learning methods, under conditions of insufficient preparation for the vast majority of stakeholders (UNESCO, 2020; World Bank, 2021). This crisis simultaneously revealed unexpected resources — the remarkable mobilisation of many teachers,

the broadcasting of lessons via national television and institutional YouTube channels, and the spontaneous development of digital professional solidarity — and deep structural divides that had been insufficiently addressed in previous digital transformation strategies: glaring inequalities in access to equipment and connectivity between urban and rural areas, and between affluent and disadvantaged families; a massive shortfall in teacher training in digital distance learning methodologies; and the weakness of platform infrastructure in the face of simultaneous, mass usage (Pokhrel & Chhetri, 2021; Alami et al., 2020; CSEFRS, 2020). These divides have highlighted the fact that the digital divide is not merely a matter of unequal access to equipment, but a profound inequality in digital capabilities — in Sen's (1999) sense — which refers to the skills, practices, cultural resources and institutional support available to educational stakeholders to varying degrees depending on their social and geographical position (Warschauer, 2003; van Dijk, 2020).

From an organisational perspective, the digital transformation of the Moroccan education system illustrates with particular acuity the tensions characteristic of the transition from a hierarchical model to an ecological model. The Regional Academies of Education and Training (AREF), which constitute the system's intermediate level of governance, exemplify these tensions: positioned between a central authority driving reforms and schools struggling to implement them due to a lack of resources and appropriate skills, they must invent new roles — pedagogical support, institutional mediation, facilitation of local innovation — that do not always correspond to their current institutional capacities or to their organisational culture, which has historically been shaped by a logic of administrative control (Alami et al., 2020; CSEFRS, 2019). This repositioning of the AREFs as actors in distributed adaptive governance — in the sense of the principles developed in our conceptual framework — constitutes one of the most decisive organisational challenges of Morocco's educational transformation, and one in which public policies have, to date, invested the least in terms of institutional capacity-building (MEN, 2019; Benali & Zaid, 2020).

These dynamics are set against a backdrop of multi-level governance (Marks & Hooghe, 2004), where national policies must be reconciled with the contrasting territorial realities of a country marked by profound regional disparities — between Greater Casablanca-Settat and the regions of Drâa-Tafilalet or Guelmim-Oued Noun, the gaps in digital infrastructure, teacher qualifications and school performance remain considerable (HCP, 2020; World Bank, 2018). Reducing these territorial inequalities is a prerequisite for the success of Morocco's digital transformation in education, and serves as

a reminder that, to be truly inclusive and sustainable, the platform ecosystem must incorporate the dimension of spatial justice (Soja, 2010; Harvey, 2008) into its founding principles — a dimension that digital transformation strategies based on aggregated national indicators systematically tend to underestimate.

4. Discussion: Towards an ecological paradigm of educational transformation

The analyses developed in the preceding sections converge on a central theoretical proposition that constitutes the main thesis of this article: the transformation of education systems in the era of hyper-digitalisation calls for a paradigm shift which, beyond organisational and technological adjustments, touches upon the very epistemological foundations of our way of thinking about education, its institutions and its aims. The mechanical paradigm—which has dominated educational thought from the Taylorist and Fayolist rationalisations of the early 20th century through to the neo-managerial reforms of the 1980s–2000s, via the accountability and standardisation policies inspired by New Public Management (Hood, 1991; Pollitt & Bouckaert, 2011)—must give way to an ecological paradigm, better suited to accounting for the complexity, interdependence, non-linearity and self-organising dynamics that characterise contemporary hyper-digitalised education systems (Morin, 1990; Stacey, 1996; Davis & Sumara, 2006). This paradigm shift is not merely a conceptual enrichment: it entails a profound revision of the instruments of public action, the criteria for evaluating educational policies and the modes of legitimising institutional decisions (Kuhn, 1962; Lakatos, 1978).

This paradigm shift is part of a long tradition of critical educational thought which, from Dewey (1938) to Freire (1970), via Illich (1971) and more recently Biesta (2010), has consistently resisted reductionist tendencies and upheld the irreducible complexity of the educational act in the face of the logic of efficiency and rationalisation. What hyper-digitalisation brings that is fundamentally new to this history of educational ideas is less a break with these humanist traditions than an intensification of the contradictions that have run through them since their inception: between the transmission and construction of knowledge, between the standardisation and individualisation of educational pathways, between systemic efficiency and individual emancipation, between the universalism of principles and the contextualisation of practices (Biesta, 2010; Pinar, 2004; Giroux, 2011). Hyper-digitalisation radicalises these tensions by giving them a new techno-political dimension, in which digital platforms are no longer merely tools serving pre-established educational ends, but actors in their own right who

help to redefine those ends themselves (Selwyn, 2019; Williamson, 2017; Facer, 2011).

4.1. Six strategic reorientations for an ecological paradigm

The ecological paradigm we propose entails at least six major strategic reorientations for those involved in educational transformation, which we will outline in turn.

The first reorientation concerns multi-level, multi-stakeholder governance. The ecological paradigm calls for the construction of governance frameworks that link national, regional and local dimensions within a logic of active subsidiarity (Marks & Hooghe, 2004; Ansell & Gash, 2008), and which integrate private, voluntary, academic and community stakeholders into inclusive deliberative forums. This polycentric governance — in the sense used by Ostrom (1990) — does not imply a weakening of the state's role, but rather its transformation: from a prescriptive and controlling state to a strategic and regulatory state, capable of defining shared policy directions whilst leaving sufficient scope for adaptation at intermediate and local levels (Le Galès, 2014; Pierre & Peters, 2000). In the Moroccan context, this reorientation entails, in particular, a substantial strengthening of the institutional capacities of the AREFs, whose repositioning as actors in distributed adaptive governance constitutes, as we have shown, one of the most decisive organisational challenges of educational reform (CSEFRS, 2019; Alami et al., 2020).

The second reorientation concerns the broader infrastructure policy. The ecological paradigm requires moving beyond a narrow conception of digital infrastructure reduced to connectivity and equipment, to invest simultaneously and in a coordinated manner in five complementary dimensions: technical infrastructure (connectivity, equipment, platforms), the digital skills of educational stakeholders (teachers, learners, administrators), professional digital cultures (shared representations, values and practices), organisational architectures enabling the integration of digital technology into everyday practices, and regulatory frameworks ensuring data protection and institutional sovereignty (Warschauer, 2003; van Dijk, 2020; Selwyn, 2016). This integrated view of digital educational infrastructure aligns with research on *digital capabilities*, which emphasises that access to technologies only translates into real educational benefits if stakeholders possess the cognitive, social and institutional resources necessary for their effective adoption (Sen, 1999; Nussbaum, 2011; Facer & Selwyn, 2021).

The third shift calls for a context-specific approach to educational innovation. The ecological paradigm rejects

universalist approaches that seek to apply standardised technological solutions to fundamentally diverse educational contexts (Collet & Dupriez, 2013; Tikly & Barrett, 2011). Instead, it encourages situated innovations, rooted in local contexts, developed in collaboration with practitioners on the ground, and evaluated according to criteria tailored to the specific realities of each educational environment (Noffke & Somekh, 2009; Coburn & Penuel, 2016). This distinction is particularly crucial in countries such as Morocco, where the contrasts between urban and rural areas, between dynamic regions and isolated areas, and between well-resourced and disadvantaged schools, constitute structural realities that no generalist reform can ignore without risking further widening existing educational inequalities (HCP, 2020; World Bank, 2018; Soja, 2010). This need for contextualisation is not at odds with the pursuit of national systemic coherence: on the contrary, it is a prerequisite for its effective realisation, insofar as only innovations rooted in local professional practices and cultures stand a chance of spreading and becoming sustainable (Fullan, 2007; Hargreaves & Shirley, 2009).

The fourth reorientation calls for a reconsideration of the timeframes of educational transformation. One of the most profound and least theorised challenges of the hyper-digitalisation of education systems lies in what we propose to call digital heterochrony: the structural mismatch between the very short timeframes of platform logic — innovation cycles lasting a few months, constant updates to features, accelerated obsolescence of tools — and the long timeframes of institutional transformation, pedagogical adoption and changes in professional cultures (Hartog, 2003; Rosa, 2010; Virilio, 1977). This heterochrony creates specific risks for educational organisations: the risk of a permanent disconnect between tools that evolve faster than practices; the risk of technological investments becoming obsolete before they have been fully adopted; and the risk of perpetual innovation that exhausts stakeholders without producing the profound transformations hoped for (Cuban, 2001; Fullan, 2001; Sahlberg, 2011). Managing this time lag is one of the most delicate challenges for those responsible for educational transformation, and calls for strategies of deliberate temporisation — knowing how to slow down to allow for appropriation, taking the time for rigorous evaluation before rolling out changes, resisting the pressure for constant innovation — which run counter to the dominant logic of acceleration in discourses on digital transformation (Rosa, 2010; Sahlberg, 2011; Biesta, 2022).

The fifth shift, which cuts across the previous ones, concerns digital sovereignty in education. In a context where the world's leading educational platforms — Google Workspace for Education, Microsoft Teams for Education, Zoom,

Coursera, edX — are developed, controlled and monetised by private actors from a handful of countries in the Global North, the education systems of countries in the Global South face risks of technological and cultural dependence that warrant sustained and structured political attention (Hogan, 2016; Macgilchrist, 2019; Zuboff, 2019). The concept of digital educational sovereignty — understood as the capacity of states and educational institutions to define, control and steer the digital infrastructures that mediate their teaching, learning and research activities — constitutes a strategic issue that extends beyond the educational sphere alone to touch upon questions of cultural, cognitive and political sovereignty (Benhamou, 2022; Musiani et al., 2016). Building local capacities for the development, adaptation and maintenance of digital educational resources — free software, open educational resources, shared regional infrastructure — constitutes a partial but essential response to this challenge, which several initiatives led by UNESCO, the African Union and certain governments in the Global South are beginning to explore with growing ambition (UNESCO, 2019; African Union, 2021; Amiel & Soares, 2016).

Finally, the sixth shift concerns the integration of environmental sustainability into digital education transformation strategies — a dimension that the dominant discourse on EdTech continues to largely ignore. The ecological paradigm, true to its biological inspiration, cannot be satisfied with a conception of the digital educational ecosystem that would ignore the real environmental impacts of digital infrastructure: the carbon footprint of data centres, the planned obsolescence of equipment, and the energy consumption of machine learning algorithms (Freitag et al., 2021; Shift Project, 2019; Crawford, 2021). Promoting digital frugality in educational institutions—choosing shared and eco-designed infrastructure, extending the lifespan of equipment, and favouring lightweight software solutions—is an ethical and political responsibility for educational stakeholders, who must embody in their institutional practices the values of sustainability that they claim to pass on to future generations (Stiegler, 2015; Jonas, 1979; Biesta, 2010).

4.2. Limitations, critical perspectives

This ecological paradigm of educational transformation is not without its internal tensions and analytical limitations, which an honest discussion must identify. The first tension concerns the risk of naturalisation inherent in any ecological metaphor applied to human organisations: by speaking of ecosystems, niches, resilience and co-evolution, we risk presenting as natural and inevitable processes that are in reality the product of power relations, political decisions and institutional choices (Swyngedouw, 2010; Harvey, 1996). Critical vigilance must

be maintained to ensure that platform ecology remains an emancipatory analytical framework and not an ideology that naturalises platform capitalism. The second tension concerns the risk of romanticising complexity: invoking systemic complexity must not serve as an excuse to avoid difficult political choices, trade-offs between competing values, and decisions that entail responsibility on the part of institutional actors (Morin, 1990; Snowden & Boone, 2007). Finally, the third limitation is that of **empirical validation**: the theoretical proposals put forward in this article call for rigorous field studies—longitudinal case studies, participatory research with educational stakeholders, and international comparative analyses—which will enable the proposed conceptual framework to be tested, refined and, where necessary, revised (Yin, 2018; Flyvbjerg, 2011; Coburn & Penuel, 2016).

5. Conclusion

This article has sought to explore, through the conceptual lens of platform ecology, the profound transformations that hyperdigitalisation is imposing on contemporary education systems and the organisational models that structure them. At the conclusion of this analytical journey, it is appropriate to summarise the theoretical contributions of the approach, assess its practical implications and identify the research avenues it opens up.

The first contribution of this article lies in the conceptual distinction between digitisation and hyper-digitalisation. By showing that these two phenomena differ not in degree but in nature, we have laid the foundations for an analysis that refuses to reduce educational transformation to mere technological modernisation. Digitisation transposes existing practices onto digital media without altering their underlying structures; hyper-digitalisation, on the other hand, reconfigures the logics of action, power relations and institutionally reshapes institutional timeframes in their very substance. This distinction is not merely academic: it has direct consequences for the way in which educational policies must be designed, implemented and evaluated. A policy that treats digital transformation as merely a matter of equipment and connectivity is structurally doomed to produce disappointing results, as clearly illustrated by the mixed results of the GENIE and INJAZ programmes in Morocco.

The second contribution is the construction of an original conceptual framework — platform ecology — which coherently articulates five complementary theoretical traditions: ecological and systems thinking, the theory of complex adaptive systems, platform economics, the critical sociology of digital organisations, and the theory of adaptive governance. This framework, organised around five

fundamental principles — interdependence, co-evolution, ecological niches, resilience and distributed governance — and three organisational pillars — organisational holarchy, adaptive governance and regenerative sustainability — provides an analytical framework that transcends the limitations of sectoral and techno-deterministic approaches to offer a systemic, relational and critical interpretation of contemporary educational transformations. Its main heuristic virtue is that it simultaneously maintains the technological, human, institutional, political and environmental dimensions of educational transformation within the analytical framework, without reducing any of them to a variable dependent on the others.

The third contribution concerns the concrete organisational implications of this framework for education systems. The analysis has shown that the transition from a hierarchical and bureaucratic organisation to an adaptive and distributed one involves at least four interdependent transformations: a redefinition of educational leadership, a cross-cutting restructuring of teaching teams, a redistribution of forms of institutional authority, and a fundamental overhaul of evaluation and accountability systems. These transformations are not optional in a VUCA environment: they constitute conditions for organisational survival for educational institutions which, if they fail to implement them, risk a gradual and potentially irreversible disengagement from the digital ecosystems that surround and permeate them.

The fourth contribution is the analysis's Moroccan contextual grounding, which has enabled the theoretical proposals to be tested against a concrete institutional reality and enriched by its specific characteristics. Morocco illustrates, with particularly instructive clarity, the structural tension between centralising organisational legacies inherited from post-colonial nation-building and the structural reforms of the 1980s and 1990s, and the imperatives of adaptability, flexibility and distributed governance that digital transformation entails. The Strategic Vision 2015–2030 and Framework Law 51-17 demonstrate a genuine reformist ambition, but their organisational implementation faces structural obstacles—profound territorial inequalities, a lack of training for stakeholders, insufficient institutional capacity at intermediate levels of governance — which only a systemic and long-term approach can hope to overcome. The Covid-19 crisis, far from being a mere hiccup, has served to highlight these fractures and acted as a liberating disruption, opening windows of opportunity for organisational innovations that institutional routine had hitherto rendered unlikely.

Beyond these specific contributions, the most fundamental contribution of this article is perhaps of an epistemological

and political nature: to propose the outlines of an ecological paradigm of educational transformation as an alternative to the mechanistic paradigm that continues to dominate managerial and political discourse on digital education. This paradigm does not claim to resolve the tensions inherent in the educational act—between transmission and emancipation, between equity and excellence, between universalism and contextualisation—but it proposes to address them with conceptual tools better suited to their irreducible complexity. It asserts that education, in all its institutional forms, remains above all a practice grounded in human relationships, shared values and a collective promise—a promise to transmit knowledge, to emancipate and to build society—which no technology, however powerful, can either replace or invalidate (Dewey, 1938; Freire, 1970; Biesta, 2010).

The limitations of this article implicitly define the **research agendas** that future work should address. On a theoretical level, the framework of platform ecology would benefit from being brought into a more systematic dialogue with work on educational justice (Fraser, 2008; Tikly & Barrett, 2011) and decolonial studies of technology (Couldry & Mejias, 2019; Ndlovu-Gatsheni, 2018), in order to more explicitly integrate the dimensions of global power and digital coloniality that permeate the educational ecosystems of the Global South. At the empirical level, rigorous longitudinal case studies — conducted in Moroccan schools representative of the diversity of local contexts — would enable the analytical proposals put forward here to be tested, refined and revised (Yin, 2018; Flyvbjerg, 2011). Participatory research involving practitioners on the ground—teachers, school heads, and education authority officials—in the co-construction of analytical tools and policy recommendations would also constitute a particularly promising methodological approach for producing knowledge that is both rigorous and directly useful to practitioners (Coburn & Penuel, 2016; Noffke & Somekh, 2009).

Ultimately, conceiving of an ecology of platforms for education means refusing to allow digital transformation to unfold solely according to the logic of the market and constant technological innovation. It is to assert that education systems are common goods — in the sense of Ostrom (1990) — whose governance requires forms of collective deliberation, political regulation and intergenerational accountability that transcend platform logic and the timeframes of disruption. Finally, it is a reminder that the central issue in any educational transformation is not technical but ethical: not how to digitise education, but to what ends, according to what values and for whose benefit — questions to which neither algorithms nor markets can answer in place of societies and their institutions.

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