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Hugues Jeannerat, Anna Butzin, Luis Carvalho & Jesper Manniche

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Transformative knowledge regions: Bringing knowledge to the frontstage of transformative innovation

Hugues Jeannerat[1], Anna Butzin[2], Luis Carvalho[3] & Jesper Manniche[4]

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Abstract

While knowledge has long been central to theories of innovation-led regional development, its conceptualization within the emerging transformative innovation paradigm has remained largely implicit and undertheorized. This paper draws on insights from sustainability transitions, organizational learning, and higher education studies to develop a perspective on the action-oriented nature of knowledge, as it increasingly associates with the matters of directionality, materiality and structuration. Based on this, we articulate an idea of transformative knowledge through a triple lens, emphasising interdependencies between knowledge for action (goal- and mission-oriented), knowledge by action (generated through experimentation), and knowledge as action (situated in practice and everyday life). We apply this lens to discuss the outlines of transformative knowledge regions, proposing an expansion in the repertoire of regional innovation interventions. In doing so, the paper broadens the epistemic contours of knowledge in regional development and contribute to current debates on challenge- and mission-oriented regional innovation policy.

Keywords: *transformative learning; sustainability transitions; regional innovation policy; mission innovation; valuation*

[1] Institutes of Sociology and Geography, University of Neuchâtel, Switzerland, hugues.jeannerat@unine.ch
[2] Institute for Work and Technology, Westphalian University of Applied Science, Germany, butzin@iat.eu
[3] CEF.UP, School of Economics and Management, University of Porto, Portugal, lcarvalho@fep.up.pt
[4] Centre for Regional and Tourism Research, Denmark, jesper.manniche@crt.dk

1. Introduction

In recent years, mounting grand challenges—ranging from climate and demographic shifts to resource scarcity, ecosystem degradation, and growing political divides—have intensified the need to re-evaluate long-standing regional development paradigms (e.g., Fratesi, 2025; Karlsen et al., 2025). These challenges have not only exposed the limitations of competitiveness-oriented policies but also highlighted the urgency of new types of regional development approaches. In Europe, this shift is exemplified by a growing reconsideration of the "knowledge-for-growth" paradigm that underpinned the Lisbon Agenda (Benner, 2020). In its place, increasing policy attention has been directed to the European Green Deal (European Commission, 2019), to the reinvigorated idea of mission-oriented innovation (Mazzucato, 2021) and to "transformative" innovation (Schot & Steimueller, 2018; Lundvall, 2024). These developments have contributed to a broader normative turn in regional innovation policy, where knowledge and innovation are increasingly framed as means to address wider societal challenges (Uyarra et al., 2019).

This reorientation has sparked new research agendas at the intersection of regional studies, economic geography, and sustainability transitions (e.g., Boschma et al., 2017; Binz et al., 2025; Chlebna et al., 2024; Tödtling et al., 2022; Uyarra et al., 2025; Vale et al., 2024). Yet, despite the renewed attention, the nature and the role of knowledge within a transformative (regional) innovation paradigm remained unstated and unexplored. While regional innovation studies have long examined the relationship between knowledge and innovation – through the lens of combinatorial knowledge dynamics (Asheim et al. 2011; Manniche et al., 2017, Strambach & Klement, 2012), innovation system models (Cooke et al., 2001; 2007), knowledge relatedness (Neffke et al., 2011), learning regions (Morgan, 1997; Cooke, 2018), among others – the question of how (and which) knowledge contributes to systemic, place-based transformation has been rarely addressed head-on. The matters, policy issues and epistemological framing of knowledge in recent regional transformative innovation research has been largely inherited from the previous innovation paradigm.

Under this backdrop, we argue that it is necessary to revisit existing assumptions and extend our perspective on the role of knowledge in regional development, particularly in light of the societal challenges and mission-oriented demands currently shaping innovation policy discourse. In this conceptual paper, we thus ask: *How can knowledge and learning become transformative?* And *what are the implications for regional innovation and policy?* By addressing these questions, we seek to introduce new perspectives into recent interdisciplinary work at the intersection of regional innovation studies and sustainability transitions, drawing on complementary insights from education studies (e.g. Merzirow, 2000; Sterling, 2011) and organizational and social learning scholarship (e.g., Cook & Brown, 1999; Ibert, 2007) — particularly the idea that knowledge is situated and inseparably linked to practice and action. The paper puts forward three main contributions. First, we propose a definition of transformative knowledge as knowledge that is inherently action-oriented, unfolds in multi-actor and multi-local participatory contexts, and continuously shaped by societal valuation processes. Second, we develop a distinction between knowledge *for*, *by*, and *as* action, to clarify how knowledge relates and contributes to current transformation challenges. Third, we develop the idea of "transformative knowledge regions" as places where knowledge *for*, *by*, and *as* action is generated, mobilized, enacted, and institutionalized to support transformative innovation goals.

The remainder of the paper is structured as follows. Section 2 revisits the evolution from a knowledge-intensive to a transformative innovation paradigm, outlining how the role and understanding of

knowledge has shifted in regional development discourses. Then, Section 3 broadens the scope of the discussion by identifying three key matters of knowledge that are central in a transformative innovation perspective: directionality, materiality, and structuration. Section 4 conceptualizes "transformative knowledge" and introduces the distinction between knowledge *for*, *by*, and *as* action, while Section 5 makes use of that distinction to develop the notion of "transformative knowledge regions". Section 6 provides concluding remarks on the usefulness of such an approach for regional research and policy.

2. Knowledge: from the spotlight to the backstage of innovation

Knowledge has been at the centre of regional and national education, science and innovation policy over the past thirty years. Yet, during the shift from the "knowledge-intensive" paradigm associated with the Lisbon Agenda to the contemporary "transformative" paradigm in response to grand sustainability challenges, it can be argued that the understanding of knowledge has been put backstage both in research and policy agendas. We briefly outline and distinguish the characteristics of the two paradigms below, highlighting the place and role of knowledge in each of them (see also Table 1).

2.1 The knowledge-intensive paradigm: Innovation for competitiveness

In the year 2000, the European Commission launched the *Lisbon Agenda*, aiming to make Europe "the most competitive and the most dynamic knowledge-based economy in the world" (European Council 2000). This agenda influenced successive generations of innovation and regional development strategies, ranging for cluster policy to *smart specialisation* (Foray, 2018; Terstriep & Lühtje 2018). Retrospectively, this paradigm can be schematized as "knowledge-intensive", in which knowledge took centre stage – valued as a driver of national and regional competitiveness, underpinning technological innovation and supporting immaterial activities in culture- and service-based industries (Jeannerat & Crevoisier, 2016). Within this paradigm, research and policy envisioned an economy "directly based on the production, distribution and use of knowledge and information" (OECD, 1996, p. 3). Core policy efforts focused on R&D investment – understood as expenditures to enhance, acquire, or diffuse knowledge—alongside the promotion of creative industries and the cultivation of a highly educated workforce. The overarching aim was to ensure well-functioning innovation systems, continuously capable of translating new knowledge into tradable goods and services (OECD, 2011).

Within this paradigm, knowledge is conceived both as the product of interactive learning processes at the micro level and as a broader socio-economic asset. Innovation system scholars (e.g., Asheim et al., 2019; Fagerberg, 2017; Cooke et al., 2007) emphasized that knowledge arises from interactions among individuals, organizations, and communities, shaped by shared practices, institutions, and collective learning. Emphasis is given to knowledge exchange between firms, intermediaries, and research and education institutions, with public policy aimed at addressing system failures (Schot & Steinmueller, 2018). Knowledge is seen as an economic resource with intrinsic value—central to innovation, societal progress, and especially regional economic diversification. Evolutionary economic geographers (e.g., Boschma, 2004; Boschma & Martin, 2010) further highlighted its path-dependent nature, whereby localized knowledge exchange and cumulative learning processes shape both the opportunities and limitations for future diversification.

While being a target of policy intervention, knowledge is treated as politically neutral in this paradigm. It is valued for its instrumental capacity to foster innovation in and for markets (Jeannerat, 2024). Rather than being guided by explicit public missions or societal goals, knowledge generation and use are largely driven by scientific inquiry and market "pull" forces (see Di Stefano et al., 2012, for a review). Public policy, in this context, plays an enabling role—aimed at creating favourable conditions for knowledge-intensive activities without prescribing specific directions or outcomes.

2.2 The transformative paradigm: Innovation with societal and systemic goals

Contemporary grand societal challenges call for an expanded understanding of knowledge, namely one that moves beyond the Lisbon Agenda's focus on economic competitiveness to explicitly address broader societal issues. Schot and Steinmueller (2018) describe this as a potential paradigm shift in innovation policy. Yet, although innovation now sits at the forefront of the transformative paradigm—as the idea of mission-oriented innovation epitomizes (Mazzucato, 2021)—the role of knowledge and learning has remained largely implicit (van Poeck et al., 2020).

In its essence, a transformative innovation paradigm introduces a more goal-oriented approach to innovation, whereby innovation efforts explicitly target societal problems, particularly (but not exclusively) those related to environmental sustainability (Schot & Steimueller, 2018). It entails setting normative goals for innovation policies (e.g., related to the Sustainability Development Goals – SDG), emphasizing solutions that can trigger long-term societal transformation. Yet, the challenge for innovation does not rest anymore (only) in developing new products or services with market appeal, or "solutions" to challenges, but on innovating entire production and consumption systems, particularly those underpinning the delivery of essential societal functions such as energy, mobility, or food (Geels, 2024; Grillitsch et al., 2021). In this broader framing, knowledge is not only tied to production and technological progress, but also interwoven with culture, social innovation and new value systems, and thus prone to contestation and even denialism (Fraune & Knodt, 2018).

In a transformative innovation paradigm, rather than emphasizing knowledge generation per se, attention turns to the technical configurations and socio-institutional frameworks that innovation actors simultaneously mobilize and seek to transform. It expands the set of relevant actors beyond firms and research institutions, bringing civil society, NGOs, and other non-market organizations into the innovation process (Schot & Steinmueller, 2018). These actors contribute not only through advocacy or policy influence but by shaping consumption patterns, behavioural routines, social norms, and everyday practices (Rabadjieva & Butzin, 2022; Buijs et al., 2024). Within this context, knowledge increasingly functions as a medium for coordination, learning, and reflexivity rather than as a standalone input, an idea also reflected in the urban experimentation literature (e.g., von Wirth et al., 2018).

Overall, while knowledge remains essential, it operates more implicitly, reflecting a shift from knowledge as an end toward knowledge as a means for realizing systemic change (Table 1). It is true that recent research has engaged with a transformative paradigm to propose new ways to conceive regional development and innovation policy (e.g., Tödtling et al., 2022; Karlsen et al., 2025; Tartaruga et al., 2024; Vale et al., 2024; Uyarra et al., 2025, Butzin & Terstriep, 2023). However, although this body of work challenges conventional innovation logics, it rarely places knowledge itself at the centre of inquiry. Most studies continue to treat knowledge as an implicit driver, co-evolving with technology and other (innovation) system resources. What remains largely underexplored is a reconsideration of

the matter of knowledge itself, beyond the assumptions inherited from the knowledge-intensive paradigm.

Table 1: The knowledge intensive and the transformative innovation paradigm

	KNOWLEDGE-INTENSIVE INNOVATION PARADIGM	TRANSFORMATIVE INNOVATION PARADIGM
Socio-economic context	Knowledge economy / society	Grand Challenges
Development paradigm	Address innovation system failures to nurture knowledge-intensive innovation	Nurture transformative innovation to achieve systemic societal change
Research and policy matter	Knowledge as an explicit research and policy matter to foster competitiveness	Transformative innovation as focal research and policy matter (that implicitly build upon knowledge)
General research and policy question	How to make knowledge more widespread? ⇨ How to generate, share and use more knowledge in the economy?	How to reach sustainable development goals (SDGs)? ⇨ What to achieve in the economy and society (and when and where)?
Public direction of knowledge generation and use	Not explicit, politically neutral ⇨ Scientific curiosity; exploration ⇨ Articulated demand pull; selection mechanisms in existing markets	Normative directionality ⇨ Solving an existing problem ⇨ Societal transformation e.g. reaching SDGs, challenge-based

Source: own elaboration

3. Broadening the scope: three matters of knowledge

As a consequence of the above, studying knowledge within a transformative innovation paradigm requires broader analytical lenses and a rethinking of both its scope and associated challenges. In particular, we argue that three key dimensions warrant closer attention: the relationship between knowledge and directionality (3.1), materiality (3.2), and structuration (3.3).

3.1 Directionality: inquiring public missions and futures

In the knowledge-intensive paradigm, markets are seen as a fundamental selection and information devices, shaping innovation directions and providing feedback on the exploration and exploitation of knowledge (Jeannerat & Kebir 2016). However, in the context of contemporary grand challenges, markets for emerging technologies and solutions are often still in a formative stage, with demand not yet fully articulated, limiting the ability of previous frameworks in understanding the links between markets, innovation and knowledge (Weber & Rohracher, 2012). While some argue that regional innovation strategies such as *smart specialization* already embed directionality mechanisms (Foray, 2018), what is at stake in a transformative innovation paradigm is a broader social process of market creation, aiming instead to shape and structure new markets aligned with societal needs (Boon et al., 2020).

The issue of directionality and the social creation of markets has gained growing attention, particularly within sustainability transitions and innovation studies (e.g., de Graaff et al., 2025; Wanzenbock et al., 2020), as well as at their intersection with economic geography (Flanagan et al., 2022; Uyarra et al., 2025). A central argument emerging from this literature is that knowledge generation and the direction of innovation, particularly in the context of grand societal challenges, are preceded by value-ascribing processes. These processes involve a societal appraisal of problem–solution combinations and, more fundamentally, the social determination of which problems—or "missions"—are deemed "worthy" of pursuit (Hugenin & Jeannerat, 2017). In democratic settings, missions ideally emerge through deliberative and participatory inquiry, allowing for critical evaluation, justification, and iterative refinement, although power asymmetries inevitably shape these processes (de Graaff et al., 2024). From this perspective, knowledge shapes markets not merely as a resource or technological input, but by underpinning the learning processes through which societal missions are framed and legitimated (van Winden & Carvalho, 2019). Accordingly, it has been argued that there remains significant room for better understanding the societal valuation processes that underlie the identification, envisioning and legitimation of problems and innovation directions (Hugenin & Jeannerat, 2017; Fischer & Losacker, 2025).

In line with early pragmatist approaches to learning (Dewey, 1943; Thayer, 1990), public values and missions are seen as outcomes of inquiry processes by which knowledge and its objects – such as the problems deemed worth of attention – co-evolve through lived experiences and reflexive experimentation (Elkjaear 2018). Within this view, the directionality of transformative innovation is both shaped by and emerging from future-oriented learning, rather than being past dependent. As Elkjaer (2018) explains, "[w]hat follows from this orientation towards the future is that knowledge (in Dewey's terms: 'warranted assertibilities') is provisional, transient and subject to change ('fallible') because future experience acts as a corrective to existing knowledge" (p. 72). This future-oriented lens resonates with emerging perspectives in economic geography (e.g., Gong, 2024), which emphasize that knowledge and innovation are not simply the result of regional path dependencies shaped by evolutionary selection; instead, they are embedded in—and arise from—processes of collectively envisioning new futures, rooted in local contexts, social aspirations, and shared imaginaries. These processes have been shown to instill innovation and new development pathways, even when tangible resources or clearly defined opportunities have yet to materialize (Pohl, 2024).

Building on the previous discussion, and in line with a practice-based ontology of knowledge (e.g., Schön et al., 2017; Orlikowski, 2002), it can be argued that transformative knowledge is thus not static but evolves through a performative, dynamic process. It emerges from continuous, situated interactions between knowledge, its objects, and the fields of practice in which it is embedded—shaping what issues (grand challenges) are deemed significant or relevant in specific real-world contexts. In this view, cultural activities are not merely associated to 'creative industries', as in the knowledge-intensive innovation paradigm, but serve as mediating practices that engage in the interrogation of current societal challenges and the imagination of future possibilities (O'Connor, 2024). From this perspective, the scope of transformative knowledge extends beyond traditional knowledge transfer frameworks between research organization and firms operating within market structures. Instead, transformative knowledge dynamics include these and other actors jointly shaping shared understandings of problems, envisioning future solutions, and how to act together to make them possible.

3.2 Materiality: acting with and upon contingencies

As highlighted, a practice-based view argues that knowledge emerges through interactions with both actors and the material world of lived experiences (e.g., Ibert, 2007). Learning, in this sense, involves a dual dynamic: developing the ability to engage with material contingencies (or, learning by doing *and* making), and the capacity to act upon them (learning to do *and* to make). Over the past three decades, the knowledge-intensive paradigm has primarily emphasized activities that create value *around* and *upon* rather than from material goods and natural resources (Bakker & Bridge, 2022). In this perspective, learning and acting with material contingencies have been less about managing production and natural resources´ scarcity, and more about leveraging technological advancements and market value through creative activities such as design, marketing, sales, and after-sales services (Jeannerat, 2024). While materiality has begun to reappear in studies of regional economic diversification – for instance, in analyses of hydrogen value chains (Njøs et al., 2024) or the regional valorisation of industrial by-products (Angstmann, 2025)—most literature on regional innovation dynamics still tends to overlook the interdependencies between knowledge and material conditions.

It can be argued that reintegrating materiality into the knowledge debate is essential for understanding transformative innovation and significantly broadens the scope of what counts as knowledge. On one hand, acknowledging materiality means valuing not only scientific expertise but also lay knowledge rooted in everyday practices. These forms of knowledge challenge established production, consumption, and living modes by confronting them with the material realities of the world. For example, from this lens, both the scientific evidence confirming global warming and farmers' lived experiences of climate change must be considered in envisioning and debating societal transformations. On the other hand, a focus on materiality invites a shift away from elitist perspectives that equate knowledge with high technology or advanced degrees. It highlights the importance of practical skills, craftsmanship, and manual labour in enabling societal change (Moilanen & Alasoini, 2023). Sustainability transitions, for instance, will not be driven by masterplans and advanced technologies alone but through tangible actions such as insulating buildings, installing solar panels, and repairing goods, particularly in resource-scarce contexts.

Therefore, knowledge embedded in community-based practices is increasingly recognized for its potential to revitalize traditional modes of production and living in response to ecological challenges, as well as to provide a more nuanced understanding of what constitutes green skills (Fuchs, 2024). This recognition prompts for a re-evaluation of the longstanding divide between vocational and academic education, promoting the integration of intellectual, ethical, and manual activities in a more interconnected manner (Hyland, 2018). In this context, vocational education is expected to play a pivotal role in supporting industrial sustainability transitions (Persson Thunqvist et al., 2023) and is thus strongly articulated with the idea of knowledge in a transformative innovation paradigm.

3.3 Structuration: institutionalising systemic change

In the knowledge-intensity paradigm, knowledge is primarily understood as the outcome of learning processes occurring at the micro level—among individuals, firms, and other organizations. These learning interactions are seen as embedded in multi-nested innovation systems (regional, national, sectoral), which are themselves shaped by institutional arrangements, or what North (1990) termed the "rules of the game." From this lens, "an efficient system of distribution and access to knowledge is

a sine qua non condition for increasing the amount of innovative opportunities. Knowledge distribution is the crucial issue" (David & Foray, 1995, p. 40, cited in Godin, 2007). Within this framework, institutions not only help (or hamper) channel knowledge but also influence its generation and use in response to technological and market requirements.

Again, the paradigm of transformative innovation calls for a rethinking of these assumptions, and the opening of new epistemic viewpoints. Rather than treating knowledge as primarily embedded in institutional structures, knowledge in a transformative paradigm also refers to the capacity of individuals and collectives to reflect critically on their cognitive frameworks. Drawing from theories of transformative learning in higher education studies (e.g., Mezirow, 2000), this approach recognizes that innovation is not merely the result of better knowledge dissemination, but of processes through which institutionalized meaning structures are questioned and reframed. Likewise, Sterling (2011) argues that transformative learning involves a profound shift in worldviews: it is not just about improving or reorganizing systems but fundamentally "seeing things differently". This goes beyond the optimization or reconfiguration of knowledge systems, involving cultural and epistemic shifts on how individuals and organizations approach societal development. At the same time, newly reframed learning schemes must be institutionalized to shape durable change. As Urmetzer (2020) argues, transformative knowledge is not only conceptual—it involves critique, re-conceptualization, and strategic action, underpinned by awareness of systemic interrelations (systems knowledge) and the normative structures that maintain or challenge them (normative knowledge).

This resonates with the notion of structuration in transition studies (e.g., Markard et al., 2012), which emphasizes that environmental innovations must undergo sequential processes of learning and societal embedding to challenge established technologies, norms, practices, and cognitive frameworks. At the core of these institutionalization and de-institutionalization processes are not only technologies, but also knowledge and new ideas, which drive system configurations, e.g., in sectors such as energy, mobility, and food (Geels, 2024). Research addressing the geography of sustainability transitions has shown that these (de-)structuration dynamics are deeply place-based, shaped by the institutional, cultural, and socio-economic specificities of regions. Such contexts influence both the types of innovations that gain traction and the ways in which knowledge is mobilized, legitimized, and embedded into new socio-technical arrangements (Binz et al., 2025). Altogether, this dual focus on agency and structure underscores transformative knowledge as co-evolving through a dynamic interplay of critical reflection and institutionalization.

4. Towards an understanding of transformative knowledge: knowledge for, by and as action

At this stage, the previous considerations provide a foundation for further conceptualizing the notion of transformative knowledge. We argue that transformative knowledge should be understood as knowledge that is inherently action-oriented, unfolds in multi-actor and multi-local participatory contexts, and is continuously shaped by societal valuation processes. In particular, bringing knowledge back to the forefront of transformative innovation requires a nuanced understanding of its interdependent relationship with *action* (e.g., Argyris, 1993; Hölscher et al., 2023; Mach et al., 2020, Palavicino et al., 2023). Going one step further and drawing from different literature streams on knowledge and

innovation, we propose that transformative knowledge links to action in three distinct but interconnected ways, which we conceptualize as knowledge *for*, *by*, and *as* action.

Knowledge *for* action emphasizes knowledge as an instrument for action. It is generated and mobilised to achieve particular aims (e.g. developing green innovation). In many scholarly fields, this view of knowledge is applied in a 'universalist' manner in the sense that key processes and patterns of learning for individuals and organizations are seen as techno-scientific processes (Taylor & Easterby-Smith, 1999). This view of knowledge *for* action also underpins evolutionary economic geography and regional innovation system approaches (e.g. Boschma & Martin, 2010; Cooke et al., 2011), which consider the creation, use, and sharing of knowledge – as technical outputs, but also skills and competences – as essential for learning and innovation, with a discussion being on how (different types of) knowledge recombine to generate innovation (Asheim et al., 2018; Manniche, 2012). In these approaches, however, knowledge *for* action is also seen as contextually situated and endogenously created *by* action within the innovation system in which it is used, examined, and exploited, and grounded in learning by doing, using, and interacting (Jensen et al. 2007). Accordingly, innovation is considered as both an output and a driver of collective knowledge production.

While this dialectical view of knowledge *for* action and knowledge *by* action draws on an epistemology of knowledge "possession" — i.e., seeing knowledge as a resource, asset and commodity, which can be possessed, stored, shared and recombined by individuals and organizations and applied toward innovation – authors like Cook & Brown (1999) propose another, interrelated "epistemology of practice" (see also Ibert, 2007; Gherardi 2009; Orlikowski, 2002). Influenced by Dewey's (1946) pragmatist approach to knowledge and learning, Cook & Brown (1999) view knowledge as deeply intertwined with the performance of a specific practice and interaction in situated social and material context, i.e. 'knowing as action'. From this view, knowledge is not just a resource for or by action—it is action.

Yet, according to Cook & Brown (1999), 'knowledge' and 'knowing' are not competing, but complementary and mutually enriching. Knowledge is abstract (*about* something), static and not supposed to be always in use, and yet is necessary to action – e.g., think about scientific insights on soil carbon sequestration; in contrast, knowing is dynamic, concrete, relational, part of action, and something we do – e.g., how farmers interpret, adapt, and enact these principles in response to their local soil conditions, tacit ecological understanding, observation and peer exchange. The authors argue that the generation of new knowledge and new ways of knowing relates to a continuous interplay between knowledge and knowing and thus that the two epistemologies of knowledge possession and knowing in practice should be explored together – as a "generative dance" – in which organizational knowing feeds into knowledge and, conversely, is shaped by it. An immediate consequence of this concerns the understanding of the relationship between knowledge and practice: "We must see knowledge as a tool at the service of knowing not as something that, once possessed, is all that is needed to enable action or practice" (Cook & Brown, 1999, pp.387-388).

Research on transformative learning in education studies (Mezirow, 2000; 2018; Cranton & Taylor, 2012; Taylor & Snyder, 2012) resonates strongly with this perspective and offers complementary insights for our tripartite conceptualization of knowledge *for*, *by*, and *as* action. Scholars examining education approaches for fostering social transformation towards sustainability (e.g., Lange, 2012; Urmetzer et al., 2020; Stam et al., 2023; Rodriguez Aboytes & Barth, 2020) argue that transformative learning involves not only critically re-evaluating established knowledge frameworks to enable change (*knowledge for transformation*), but also actively engaging in processes of questioning and revising those frameworks through reflection and participation (*knowledge by transformation*). This learning

is grounded in practices that stimulate continuous self-critique, where knowledge is seen not as a fixed endpoint but as a provisional and evolving product of lived experience and experimentation (Elkjaer, 2018). In this sense, *knowing* becomes a dynamic, relational process, unfolding through situated interactions between knowledge and its objects, and shaped through public inquiry and collective engagement (Dewey, 1943; Holdo, 2022; Cook & Brown, 1999)—a view of *knowledge/knowing as transformation* that stresses its performative and evolving nature in response to situated grand challenges.

To understand knowledge within a transformative innovation paradigm, such a theoretical clarification on the interplay between *knowledge* and *knowing* has empirical implications. First, addressing the complexity and place-based nature of the problems and solutions targeted by innovation (*knowledge for action*) demands engaging with forms of knowledge and knowing largely neglected in the knowledge-intensive paradigm, which prioritized immateriality, global competitiveness, and elite talent (e.g., the creative class, scientists, high-tech professionals). As previously discussed, this involves examining how diverse, mundane, material, and collective practices—and the forms of knowledge embedded within them—can be recognized, mobilized, and activated (*knowledge by action*). Equally important is the need to identify and understand the cultural and political contexts, public controversies, and social movements that mediate collective "knowing how to do" transformative action (*knowledge as action*).

5. Transformative knowledge regions

To conclude our conceptualization, we discuss what the idea of transformative knowledge implies to regions, extending the tenets of territorial knowledge dynamics (Crevoisier and Jeannerat, 2009). It could be argued that in the evolving transformative innovation paradigm (Schot & Steinmueller, 2018; Lundvall, 2024), regions are not only places where knowledge is exchanged and recombined, but also arenas where knowledge is generated *for*, *by*, and *as* action in response to grand societal challenges. Viewing regional development and innovation dynamics through a transformative knowledge lens calls for revisiting conventional policy assumptions and expanding the repertoire of regional innovation interventions. In what follows, we sketch the contours of *transformative knowledge regions* by unpacking their roles, knowledge contexts, and associated policy approaches across the three dimensions of knowledge for, by, and as action (Table 2).

Table 2: Transformative knowledge regions

	What?	Where?	Policy approach
For action	Contextualizing and "situating" abstract knowledge New frameworks through which knowledge is understood	Arenas for public debate, higher education institutions, extracurricular learning activity, localized innovation challenges	Building capacities for 'knowing what to do' Initiating debate and raising awareness. Strengthening regional skills to 'make' (materialize) transformation.
By action	Experimentation, development of problem-solution combinations	Urban experiments, living labs, pilot sites, intermediary spaces, experimental governance approaches	Fostering knowledge by 'doing things' in the real-world.
As action	Knowledge embedded and embodied in production, consumption and living	Routines and practices of citizens' everyday life, social movements, communities of practice, pioneers	Making explicit the knowledge inherent to routines and practices Embedding new knowledge in routines and practices Education as every day and lifelong process

Source: own elaboration

5.1 Regions as contexts for action

Regions have been framed as localized learning contexts where diverse types of knowledge—rooted in place-based experiences, community practices, and material realities—are produced, anchored and mobilized to address socio-technical and ecological challenges (Carvalho et al., 2012; Hansen and Coenen, 2015; Binz et al., 2025). Connecting this approach to our previous discussion, and seeing regions as contexts *for* action, the underlying question to be answered is: What kind of knowledge is needed to tackle regional transformation challenges?

Regions provide contexts where abstract scientific and professional knowledge is integrated with local insight reflecting the "complexity of singular local situations" (Callon, 1999, p. 89), where non-specialists play a crucial role translating scientific knowledge into practical application. While scientific expertise and technical knowledge remains essential in a transformative knowledge paradigm, its effectiveness driving action depends on being contextualized through local forms of knowledge and knowing. This shift repositions knowledge as a tool for action rather than an abstract resource, enabling public missions to emerge through participatory inquiry, e.g., in regionally engaged universities (Kempton et al., 2021, Radinger-Peer & Stoeglehner, 2013), local innovation challenges and citizen forums for debate and problem sensemaking (Butzin et al. 2024). By critically evaluating and refining grand missions in response to local needs, co-created knowledge becomes directly applicable to real-world challenges. Through this process, regional contexts shape not only new solutions but also the

very frameworks through which knowledge is understood and applied (e.g., Jeannerat and Lavanchy, 2024).

Building local transformation capacities is a necessary precondition to be addressed by regional policies emphasising knowledge 'for' action (Wolfram et al., 2019). Citizens' and other actors' awareness about societal challenges, possible actions and future local impacts is central. Hence, important policy instruments are those facilitating the discussion of future imaginaries, such as awareness raising, public debate and participatory planning, to ensure acceptance and legitimacy of transformative measures (Gong, 2024). Another central policy domain is investing in the capacity to 'make' transformations. This includes fostering so-called green skills to materialize transitions. i.e. those of the trades and workers involved in building, maintaining, and adapting infrastructures in sectors such as energy, mobility, and housing (Moilanen & Alasoini, 2023; Fuchs, 2024). Without targeted policies to support these capacities, we posit, essential knowledge for regional transformation—already in short supply in many regions—risks being further marginalized.

5.2 Knowledge by action in regional contexts

Regions are arenas where knowledge is continuously created, activated, and mobilized through innovation and socio-technical change. As discussed, transformative knowledge simultaneously relies on institutionalized learning environments (rules of the game in innovation systems), but also emerge through experimental, participatory (yet controversial) engagements, where various actors co-develop innovation tailored to regional challenges (Hugenin & Jeannerat, 2017). From this perspective, the underlying question to be answered is: How to build an ecosystem that is supportive of such knowledge dynamics?

Insights from the literature on urban experimentation (e.g., Ehnert, 2023) are instructive here. These studies highlight how place-based, iterative processes of knowledge generation help shaping problem–solution combinations through cycles of experimentation, learning, and refinement. As regions host and organize such processes—via innovation projects, public procurement, or local sustainability competitions (e.g., van Winden & Carvalho, 2019) –, they facilitate the translation of abstract visions into concrete actions, bridging the gap between abstract knowledge and practical implementation. Furthermore, regions play a central role in institutionalizing new learning modes by enabling the consolidation of alternative knowledge frameworks and governance structures that support longer-term transformative change (Uyarra et al., 2025). In this way, regions may function as both catalysts and repositories of transformative knowledge, ensuring that insights gained from local experiments contribute to broader systemic transitions – e.g., through local place-making, partner activation, education, or the formation of new narratives (von Wirth et al. 2019).

Accordingly, policies that support knowledge *by* action can support action-oriented learning processes, where knowledge is created by 'doing things' in the real-world. It is confronted with the complexities of routines in the citizens' everyday life which provide direct feedback and allow a greater precision of knowing what works (and what does not work). Examples of knowledge by action refer to what is well-known as living labs, pilot sites, intermediary spaces, or experimental governance approaches (Rizzo et al., 2021). These approaches follow the overall aim to test how (and if at all) solutions can be embedded and practiced in their respective context (Fuenfschilling et al., 2019).

5.3 Regions as contexts to perform knowledge (as action)

Beyond being sites of knowledge production and application, regions contextualize how knowledge is framed, contested, and enacted through practice (e.g., Ibert, 2007). Likewise, transformative knowledge is not merely an accumulation of information, but an evolving and performative process shaped in collaborations, public discourse, grassroots and civil society activities (e.g., Pflitsch et al., 2024). Hence, an important question for transformative knowledge regions is: How is knowledge performed and acquires meaning?

Material conditions and everyday practices play a crucial role in this process. Knowledge is not only applied but also re-thought and re-made in response to changing circumstances. Engaging with both the material and social dimensions of transformation allows regional actors to create spaces for action that challenge existing structures, weaving memories of past situations with new envisioned collective futures (Feola et al., 2023). In this vein, Gong & Truffer (2024), argue that place-situated imaginaries of actors should be integrated as a lever of regional transformation. Likewise, Hallin et al. (2021), taking a performative lens, describes how evolving sustainability meanings in a large urban redevelopment project became situated in place and time, associated with lived experiences, histories, values and technologies.

From this perspective, a relevant yet overlooked policy aspect is the recognition of regions as 'living' spaces where experiential learning, production, consumption take place. Policies that frame transformative knowledge 'as' action are required to focus on the knowledge embedded in lived experiences—knowledge that manifests in 'knowing how to do', also found in the practice of social movements, communities of practice, and pioneering local initiatives – e.g., think about evolving sourcing practices of green energy advocates and pioneering local community groups (Carvalho & Lazzerini, 2018). Moreover, despite its ubiquity, knowledge in action often remains implicit, making its activation and application in solution development a challenge. From a policy perspective, an important step is the interpretation and critical examination of existing routines and practices in collaboration with the actors who shape them. However, routines and practices should not be seen as static inputs for transformative knowledge policies. Instead, they function as evolving vectors of change, capable of incorporating new knowledge and enabling transformative departures from established patterns. In this context, education must be understood as an everyday and lifelong learning process (Sterling, 2011), embedded within regional policies that foster continuous knowledge adaptation and renewal.

6. Concluding remarks

In this paper, we have argued for the relevance of a more capacious view on the nature of knowledge in addressing the challenges faced by regions in transformative, mission-oriented innovation (Uyarra et al., 2025; Tödtling et al., 2022). While the knowledge-intensive paradigm placed knowledge at the center of innovation policy, it often relied on a narrow and implicit understanding – one that overlooked how knowledge is materially situated, shaped by societal valuation processes, and entangled with broader processes of structuration and systemic change (e.g. Jeannerat, 2024). This inherited view has constrained both research and policy from fully recognizing the diverse and situated ways in which knowledge contributes to and can influence processes of regional transformative innovation. Thinking in terms of *knowledge for, by, and as action* allows us to better grasp how knowledge not only informs solutions (*for*), but also emerges through experimentation and action (*by*) and is dynamically enacted in practices and routines (*as*). We argue that this framing is helpful in recognising that knowledge does not merely serve innovation, but actively shapes how societal challenges are identified, problematized, and tackled in regionally situated ways.

We see the notion of transformative knowledge—understood as inherently action-oriented, co-produced through multi-actor and multi-local participatory processes, and continuously shaped by societal valuation—as offering fertile ground for integrating perspectives across diverse research communities. To broaden the epistemic contours of knowledge, we have combined insights from work at the interface of economic geography and sustainability transitions (Binz et al., 2025), organizational learning research (Cook & Brown, 1999; Ibert, 2007), and higher education studies (Merzirow, 2000; Sterling, 2011), the latter of which has received comparatively much less attention in regional innovation research. Each of these strands contributes valuable insights into how knowledge is created, mobilized, and legitimized—yet often in isolation. We therefore call for further research to explore these connections in greater depth, as we believe they promise for a better understanding on the articulation of knowledge and innovation in the comtemporary transformative paradigm.

As argued, placing transformative knowledge at the heart of regional transformation calls for new extensions in policy thinking. Transformative knowledge regions require policies that are both process- and solution-oriented. This means fostering spaces for collective sensemaking (knowledge *for*), supporting experimental and adaptive practices (knowlefge *by*), and embedding learning in everyday social and material routines (knowledge *as,* or *knowing*). Regional innovation policies must thus go beyond standard innovation and collaboration projects. We see the proposed framework of transformative knowledge regions as a first step outlining key dimensions for such an agenda, while calling for further deepening and reflexivity around its implementation. The literature on experimentation (e.g., von Wirth et al., 2018) has provided key insights on related types of interventions, but has largely focused on urban or localized initiatives. The growing regional engagement with these interventions (Butzin et al., 2024) opens promising avenues for broadening their appplication and reflexively analyse their transformative potential.

Naturally, advocating for the reintroduction of knowledge as a central focus in research and policy discussion on transformative innovation does not imply that knowledge is the sole lever or factor that matters. Rather, we argue that a systematic knowledge-based perspective on transformative innovation is a pertinent lens for renewing, extending and finetuning current regional and innovation policy agendas (Stam et al. 2023, Van Poek et al. 2020). In turn, this reassessment leads to further reconsidering the knowledge-intensive paradigm, which continues to underlie most major policy frameworks. The objective is to broaden it in ways that respond to the contemporary grand challenges, while preserving the positive achievements of the last two decades of education and innovation policies (i.e., not "throwing the baby out with the bathwater"). This means building upon the established successes—such as a well-educated population, high-end technologies and creative industries—while addressing emerging societal challenges.

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Institut Arbeit und Technik

Westphalian University
Institute for Work and Technology
Munscheidstr. 14
D-45886 Gelsenkirchen

Fon +49 (0) 209.17 07
Fax +49 (0) 209.17 07 110
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