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European Industry 5.0 in Action: Local Strategies for a Sustainable Human-Centric Future

Editors:
Tea Golob
Matej Makarovič


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Kataložni zapis o publikaciji (CIP) pripravili v Narodni in univerzitetni knjižnici v Ljubljani

COBISS.SI-ID 271642883
ISBN 978-961-7124-30-9 (PDF)

First published in 2026 by
Institute for Local Self-Government Maribor
Medvedova ulica 12, 2000 Maribor, Slovenia
www.lex-localis.press, info@lex-localis.press

For Publisher:
prof. dr. Boštjan Brezovnik, director

Price: free copy

Acknowledgement: This book was co-funded by the Erasmus+ programme of the European Union, Key Action: Erasmus+, Jean Monnet, Action Type: Jean Monnet Chair, Project Reference: IC4EU - ERASMUS-JMO-2024-CHAIR / Grant agreement 101174060 — IC4EU — ERASMUS-JMO-2024-HEI-TCH-RSCH. More information on the IC4EU project is available at: https://www.jeanmonnetchairic4eu.com/. Publication also co-funded by ARIS Research Programme P5-0445.

Co-funded by the European Union

JeanMonnet Chair
Inclusive Communities for European Industry 5.0

Funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or the European Education and Culture Executive Agency (EACEA). Neither the European Union nor EACEA can be held responsible for them. The European Commission's support for this publication does not constitute an endorsement of the contents, which reflect the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

https://doi.org/10.4335/2026.2 ISBN 978-961-7124-30-9 (PDF)

Available online at http://www.lex-localis.press.

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Maribor, 2026

European Industry 5.0 in Action: Local Strategies for a Sustainable Human-Centric Future

TEA GOLOB & MATEJ MAKAROVIČ [1]

Abstract The edited volume European Industry 5.0 in Action: Local Strategies for a Sustainable, Human-Centric Future brings together interdisciplinary perspectives showing how to make existing and emerging technologies more human-centric, sustainable and resilient. Based on concrete conceptual and empirical examples, the volume highlights the role of various skills development, critical thinking lifelong learning, and individual well-being as essential components of industrial development, which lies in the heart of European policy strategic orientation. It offers diverse perspectives on Industry 5.0 illustrating how new technologies, social innovations, and eco-socially responsible practices at the local level are shaping the vision of Industry 5.0. It addresses the European industry as the multidimensional concept enabling to provide societal prosperity beyond the economic growth and needs all across the EU. By connecting global technological developments with locally grounded strategies, it offers valuable insights for researchers, policymakers, business leaders, and civil society actors who seek to understand and employ the elements of Industry 5.0 for inclusive and sustainable development. The volume also highlights the importance of bottom-up approaches and locally based policies in ensuring that technological progress supports cohesive and thriving communities around the European Union.

Keywords: • Industry 5.0 • sustainable development • local sustainable practices • deliberative democracy • digital competences • human well-being

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https://doi.org/10.4335/2026.2 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

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Introduction

Understanding Values, Cognitive, Political and Social Aspects of European Industry 5.0

TEA GOLOB & MATEJ MAKAROVIČ [1]

Debates about industrial revolutions usually begin with technological advancements, move on to economic effects and then proceed to broader social, political, cultural and environmental contexts. Some kind of technological determinism was at least implicitly present in these concepts: a new technology solution is invented and implemented – and people, society and culture are supposed either to adapt to it or to perish.

The first industrial revolution or Industry 1.0 brought forward one of the most profound changes in human history – replacing the old agrarian society and the remnants of feudalism with industrial capitalism. Industry 2.0 that followed provided all the key sources of energy we still rely on today: electricity and fossil fuels – even the uses of solar and nuclear energy are at least rooted in this period. Every road vehicle of today – from internal combustion to battery electric cars – all the classical mass media – from radio to television – and most of the synthetic materials owe their core features and functionalities to Industry 2.0. The same can be claimed for assembly lines and mass consumption.

While Industry 2.0 brought forward a diversity of inventions unprecedented in the recorded history, Industry 3.0 and 4.0 were much more focused around a single trend that proceeded in an unprecedented speed: digitalisation. It created computers, automated factories and internet within Industry 3.0 and the subsequent cyber-physical fusion of the industry 4.0.

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https://doi.org/10.4335/2026.2.1 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

Unlike the previous industrial revolutions based on people, society and environment adapting to technological and economic changes, Industry 5.0 is not so much about revolutionary new technologies but more about upgrading and adapting technological solutions from previous industrial revolutions to the human needs, sustainable co-existence with other living beings and resilience for potential disruptions (Nerkhede et al 2025). It is primarily value-driven rather than technology driven (Rejeb et al 2025). The reason for this major paradigmatic shift is two-fold: because it is *possible* and because it is *necessary*.

The very clear focus on digitalisation within Industry 3.0 and 4.0 has made changes very rapid but also at least slightly more predictable. it seems much clearer at least *where* – i.e. in which fields – major changes can be expected and on which technological basis. This allows policies and actions that are less reactive and more proactive. The other reason why this kind of policies have become more possible is based on the regulatory potentials of the European Union. Its previous successes as well as failures have contributed to significant level of collective learning about the potentials and traps of regulation. This vast experience can provide the potential for Europe to develop as the leader in Industry 5.0 – a global example to be followed when it comes to human-centric, sustainable and resilient production and services.

However, it is not so much a matter of choice but even more a matter of necessity. The results of industrial revolutions so far have not only led to unprecedented prosperity for unprecedented numbers of people but also to enormous price that continues to be paid by people, other biological species, the environment in general – industry has remained unsustainable in the long run and overly exposed to a huge variety of risks. Classical warnings about alienation (Marx), anomie (Durkheim), iron cage (Weber) have retained a lot of their original relevance and have been upgraded with new sociological insights about distorted communication (Habermas) and social acceleration (Rosa). Destructive environmental effects rooted in Industry 1.0 and especially 2.0 have not ceased with subsequent 3.0 and 4.0 digitalisation.

On the top of that, expected further developments in the fields of artificial intelligence and synesthetic biology will lead to unprecedented changes. If Industry 3.0 and partly also 4.0 have been relatively narrowly focused on digitalisation, it is expected that the scope of what is to follow would be both deeper and broader (Suleyman and Bhaskar 2023). The achievements of previous industrial revolutions will be revisited through the development of new materials, new and smarter ways of optimising production, storage and distribution of energy, new solutions to move and communicate in combined physical and virtual spaces, smarter and more targeted medical interventions, new potentials for connecting and reorganising biological, psychological and technological features. These features will provide unprecedented opportunities to save humanity and provide its

sustainable coexistence with the rest of the planet. On the other hand, unprecedented threats to destroy the civilisation or even the humanity as such.

With this edited monograph, we emphasize that the core vision of European Industry 5.0 lies above all in a holistic perspective—one that foregrounds not only technological systems and innovation, but also awareness of the deep interconnectedness of the planetary system, which necessarily includes the technological domain. If we imagine losing access to natural resources, or if we take away all the components that enable technological devices to function, we are left with nothing. Moreover, the human existence depends on the air we breathe and require food to eat. The central idea lies in the interweaving of all environments and systems, namely the human, social, natural, and technological ones - because if we truly understand this interconnectedness, responsibility, sensitivity, ethics, and resilience on all social level follow automatically, and our practices can change.

At the level of individuals, the personal autonomy, integrity, and agency remain important, but they must be situated in the awareness of co-dependence and cooperation. At the same time, this is not merely an individual matter; it must also be transferred to other levels. The vision of European Industry 5.0 emerges from the macro environment, and it is still evolving. Not so much in terms of conceptualization, but above all because of implementation, which is a demanding task. Industry 5.0 is far from being a monolithic concept and entails different dimensions, which are implemented variously on different social levels and social contexts.

And the book addresses this challenge by enveloping interdisciplinary and multi-case perspective based on concrete conceptual and empirical examples, showing how the European Industry 5.0 principles can be implemented across various sectors such as digital services and media literacy, education, circular economy. It considers the advantages of the technological development that have merged the social spaces, facilitated the interactions and knowledge transfer.

The people are bound to each other as they have never been in the past, with opportunities that can lead to a more harmonious and better life for all living beings. However, there is a need for thorough changes in practice on all social levels that book addresses. By that, it contributes to the contemporary debates not only on industrial transformation but even more on the societal, and value orientated. While well-coordinated supranational regulation – as provided by the European Union – is essential for Industry 5.0, it would be a grave mistake to rely solely on top-down and centralised approaches. Instead, bottom-up, localised, decentralised and community-based actions are required. This is the central emphasis on this book.

Structure of the book

Since Industry 5.0 is above all value-based, the first part of this book proposes the value core for Industry 5.0 – to focus on humanity seeing it as an integral part of Earth. The chapter by Tea Golob and Matej Makarovič thus presents planet-centred awareness as the basis of ultimate concerns for both bringing humanity together and connecting it to the whole planet. This awareness is based on well-established facts about our planet as an all-encompassing system of living species and their environments deeply interdependent from each other. However, it runs counter some two deeply rooted ideological divisions: overemphasising the distinctions between us and them in human communities and seeing humanity as being separated from the natural world. Industry 5.0 and any positive prospects for humanity and human civilisation are only conceivable if these divisions are overcome. Nevertheless – this would be impossible if planet centred awareness becomes simply a new religion as this would only generate new distinctions between the believers and non-believers. Therefore, the chapter on planet-centred awareness introduces its crucial relationship with meta-reflexivity. The value basis of Industry 5.0 cannot be based on any kind of blind faith but on persisting critical and self-critical (inner) dialogues required to develop, maintain and elaborate planet-centred values.

Critical reflexivity related to Industry 5.0 is inconceivable without knowledge. The second part of the book thus addresses the cognitive basis of Industry 5.0: selected aspects of production and distribution of knowledge. The chapter by Maruša Gorišek focuses on the complex relationships between scientists, politicians and general public. Through the analysis of partnerships within the Association of Municipalities and Towns of Slovenia (Skupnost občin Slovenije), she discovers that local communities possess significant potential for collaboration among all three actors and addresses the potentials of deliberative democracy at the local level. The latter are strongly conditioned by proper organisation and well-informed citizens.

As the prevalence of the latter is far from self-evident, the chapter by Mateja Rek reveals a fundamental gap between current media education practices and the requirements for Industry 5.0. Media education must move beyond teaching functional digital skills toward developing "meta-reflexivity"—critical self-reflection enabling individuals to question algorithmic influence, understand encoded values in data systems, and recognize broader socio-economic forces structuring digital environments. Industry 5.0 emphasis on human-machine collaboration demands citizens capable of ethically co-creating with intelligent systems rather than passively consuming content.

The need for co-creation calls for different teaching and learning approaches. A viable way in this regard is presented by Klavdija Zorec. She studies the cases of student-led work-integrated problem-based learning at the Faculty of Information Studies. Her results demonstrate that problem-based learning – when authentically embedded in community

contexts – can both enhance student development and generate tangible solutions to real societal challenges. The model offers a transferable approach for higher education institutions seeking to strengthen local engagement, support digital and green transitions in underserved areas, and cultivate socially responsible graduates equipped for complex professional environments.

The third part of the book is focused on the political visions and political contexts of Industry 5.0. It begins with the chapter by Alenka Pandiloska Jurak who explores the presence of human-centricity, sustainability and resilience as its core pillars in the macro-regional strategies in the Baltic Sea Region, Adriatic Ionian Region, Danube Region, and Alpine Region. She notes terminological inconsistencies across macro-regions that complicate policy evaluation, obscure fund allocation tracking, and undermine systematic assessment of the EU industrial policy implementation. She calls for measurable indicators of Industry 5.0, further alignment of macro-regional objectives with the EU industrial policy and promoting capacity building through upskilling, digital innovation hubs, and cross-border research collaboration.

The implementation of Industry 5.0 may be seriously hampered by deficiencies in political legitimacy – as addressed in the chapter by Matevž Tomšič. Leadership vacuum, problem-solving failures, declining trust and deficiencies in common European identity may be a serious obstacle when confronting external authoritarian threats and internal destabilising forces, such as populism, political extremism and ideological divisions. He advocates going beyond both centralist and sovereigntist approaches and instead base the policies on thoughtfully allocating responsibilities across European, national, and local levels while demonstrating genuine leadership addressing citizen concerns.

The multi-level approach to governance for Industry 5.0 is further elaborated in the chapter by Tamara Besednjak Valič, Erika Džajić Uršič and Janja Lozar. They examine how multi-level stakeholder governance enables or constrains rural bioeconomy development aligned with the Industry 5.0 principles in Slovenia, Montenegro, and Baden-Württemberg. They identify the need for institutions capable of implementing rather than merely formulating strategies, stable cooperation networks persisting beyond project cycles, and trust-based collaboration with inclusive cognitive frames valuing local expertise. The rural bioeconomy cannot rely on technology or markets alone. It requires sustained cooperation, embedded human-centric values, and translating strategic ambition into durable regional transformation consistent with inclusive sustainable development.

In the final part of the book, the chapters are focused on the community well-being – through selected human centric features of the emerging Industry 5.0. Jana Krivec and Tjaša Stepišnik Perdih focus on the significance of psychological safety as experienced at the individual level. They demonstrate that psychological safety is not merely an

organizational or team-level construct but a broad, socially embedded phenomenon extending beyond workplace boundaries. Creating genuinely human-centred work environments requires attention not only to organizational practices but also to employees' broader social contexts, material security, and personal well-being—acknowledging the inseparability of work life from community and personal life.

The same two authors then elaborate on the use of Field-Development-Demands (FDD) Loop as an integrated framework operationalizing Industry 5.0's human-centric vision. Their framework distinguishes between horizontal development (expanding skills) and vertical development (qualitative transformation in meaning-making). Human Digital Twins serve as active regulators operating across four functional layers: sensing, modelling, simulation, and adaptive. They demonstrate that human-centric transformation is achievable through theoretically grounded, culturally sensitive, ethically governed frameworks combining psychological science with adaptive technology.

The integration of psycho-social and technological aspects is also analysed by Anja Janko who focuses on how virtual reality (VR) simulations of stressful school scenarios can help children confront anxiety-provoking situations in safe, controlled environments. A pilot study involving students with high anxiety found that 65% of students no longer felt anxious about starting at a new school after VR therapy. The author argues that VR represents a transformative step in child mental health care, combining proven exposure therapy principles with developmentally appropriate, engaging technology. With proper professional supervision and ongoing research, it can become a standard component of preventive and therapeutic mental health services in schools.

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Part I

Values and Reflections for Living with European Industry 5.0

The Significance of Meta-Reflexivity for the Rise of Planetary Consciousness in the Context of European Society

TEA GOLOB & MATEJ MAKAROVIČ [1]

Abstract The paper considers the notion of planetary consciousness as a conceptual and analytical tool for re-thinking how societies imagine identity, belonging, governance, and responsibility on a global scale. It explores how the concept has been evolving in systemic perspectives rooted in the interconnectedness of life as observed by science, civic-activist perspectives emphasising mutual responsibility and need for cooperation, as well as more spiritual views including visions of Earth as a sacred being. It provides an empirical proxy assessment of planetary consciousness in a nationally representative sample from Slovenia. Additionally, it explores the relationship of planetary consciousness with individuals' specific mode of meta-reflexivity and discusses the practical relevance of this awareness for human behaviour.

Keywords: • planetary consciousness • meta-reflexivity • sustainability • European society • structural equation modelling

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https://doi.org/10.4335/2026.2.2 ISBN 978-961-7124-30-9 (PDF)
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1 Introduction

The article considers the notion of planetary consciousness as a conceptual and analytical tool for re-thinking how societies imagine identity, belonging, governance, and responsibility on a global scale. In that regard, it explores how the concept has been evolving in systemic perspectives rooted in the interconnectedness of life as observed by science, civic-activist perspectives emphasising mutual responsibility and need for cooperation, as well as more spiritual views including visions of Earth as a sacred being. The rising interest in the concept in various domains of human society – ranging from philosophy, scholarship, science, religions, and bottom-up civic movement – is placed in the context of one of the integral features of modernisation, i.e. increased universalism. By building on theoretical foundations, the study aims to provide an empirical proxy assessment of planetary consciousness in a nationally representative sample from Slovenia. And finally, it explores the relationship of planetary consciousness with individuals' specific mode of reflexivity as proposed by Archer (2003) – namely, meta-reflexivity – and discusses the practical relevance of this consciousness for human behaviour.

The article envisions a planetary consciousness as a transformative framework for current unsustainable, unpredictable, and rapidly changing societal conditions. It deploys a systemic perspective highlighting interconnectedness and emergent properties of social, technological and biological worlds, considering humans as an integral element of the wider Earth-system. It departs from local, national and global level of thinking about human life by placing it into the planetary context. Thus, it argues for a *planetary turn* seeing humans as inevitably interconnected with its ecosystem and the Earth (Elias & Moraru, 2015) – which is crucial for holistic understanding of the current societal challenges that go beyond economic and political domains (Riberio Mendes, 2023).

Planetary consciousness offers an alternative to predominant perspectives on the growth imperative and linear progress expansion established by classical modern developmental paradigm, which paved grounds for anthropocentric views having a devastating impact not only on biosphere but human societies as well. It has become indisputable that massive extinction has already taken place (Rothman, 2017), and by the end of the century, almost a third of plant and animal species could cease to exist (Román-Palacios & Wiens, 2020). One can hardly neglect the massive effects of the unbalanced exploitation of natural resources, heavy pollution, deforestation and other unsustainable practices on human population as well. For instance, fossil fuel-related air pollution has contributed to shorter life-expectancies on a global scale (Azimi & Rahman, 2024). Ecological crisis calls for a complete redefinition of the relationship between people and nature moving beyond the anthropocentric perspective, and simultaneously fully considering the role of digital technologies in human societies.

Digital and transport technologies combined with capitalist markets have made the humanity more interdependent than ever. Electronic media and internet have provided the greatest potentials so far for connecting people all over the globe. More recently, these audiences have been increasingly exposed to messages produced by generative artificial intelligence. One can observe various concerns around the use of artificial intelligence, increasing digitalisation and smart technologies in terms of future employment and job skills demand, but also in terms of proper skills to confront the spread of fake news and/or actively engage in social action. Individuals are continuously facing demanding challenges when navigating personal and social aspirations, relationships and life projects. It has become a daily task to define the sense of the self, which often leads to personal crises. The pursuit to building one's identity through everyday decisions—what Giddens (1991) describes as reflexive self-construction—has become anything but straightforward.

While human societies are increasingly interconnected through global consumption patterns and shared cultural influences, social cohesion has eroded (Green et al., 2011). Neoliberalism rooted in the last decades of the previous century promoted individualism that contributed to the further rise of excessive isolation, alienation and anomie. More recently, this triggered a variety of collectivist backlashes – with the strong tendencies of people to belong, to re-establish a community – both in physical and on-line domains. However, these communities are too often grounded in opposition to the "Other". Echo-chambers and filter bubbles based on on-line and classical media are reproduced contributing to increasingly extreme and exclusive perspectives (Del Vicario et al., 2016, 2017). On the macro-level, this leads to social and political polarisation within and between nation states, geopolitical instability, and armed conflicts. Together with escalating environmental crisis, technological and market forces, the effects of these are intertwined with social inequalities and further marginalization of vulnerable groups.

Through a simultaneous emphasis on connectedness with other people, with other living beings and the planet, the notion of planetary consciousness can be seen as a source of the much-needed connectedness without the othering – while harnessing the technological potentials to intensify and deepen this connectedness. Consequently, it offers the most comprehensive response not only to ecological crisis but also to the combination of rapid technological advancements, excessive individualism and major social clashes. It provides a theoretical and analytical framework for understanding how to empower and reconnect humans — with one another, with technology, and with the broader natural world – when it is based on their critical, reflective deliberations. Moreover, it offers a narrative foundation to bring people together to act collectively for achieving environmental sustainability, social solidarity, and responsible utilization of technological advancement, including AI. It provides a new lens for considering the human role in both societal and natural systems by emphasising humans as key actors in

creating future developmental paths towards a more universalistic and connected modern society.

In this regard, planetary consciousness should be associated not only with a particular value orientation and an enhanced awareness of the interconnectedness of all life on Earth, but also with individuals' ability to critically observe and reflexively deliberate on the social order, their own behaviour, and their collaboration with others. Drawing on M. Archer, we see reflexivity as an inner dialogue and intrinsic feature of the human psyche – enabling humans to consciously and strategically orient their actions, activating their personal emergent properties and thus changing the existing social structure (M. S. Archer, 2012). Through the on-going process of discernment, deliberation and dedication occurring within their reflexive inner dialogues, individuals are analysing their emotions, ideas, concerns and motives for actions.

Though everyone is reflexive, there are different modes of inner dialogue, corresponding to different individual and social contexts. In traditional societies, the dominant mode of reflexivity is the communicative one, implying that one needs confirmation from significant others before acting. Modern society – involving dense industrialization, urbanization, capitalist markets, and individualization - influences various transitions in everyday life. Consequently, it encourages autonomous reflexivity, which implies relatively self-sufficient individuals striving for personal development, successful career, and higher social status at any cost. The dynamics and uncertainties of the late modern society encourage a specific mode of critical reflexivity – called meta reflexivity. Meta-reflexivity is also crucial for igniting social morphogenesis (M. Archer, 2017), namely intended, reflexive social change.

Meta-reflexivity entails a potential to go beyond the established narratives, ideologies, identities, and requires specific values and normative ideals providing alternatives to the existing socio-cultural settings. As Archer said, it requires a driving ultimate concern referring to certain cultural ideal that fuel individuals' deliberations and actions (M. S. Archer, 2003). To achieve more sustainable and favourable living conditions, a specific cultural ideal oriented toward the planetary good is needed.

The article therefore merges the concept of the planetary consciousness with the particular value orientation and ultimate concerns on the one hand, and the capability for critical reflexive thought on the other. In addition, we examine how planetary consciousness is influenced by the ways how people interact with digital technologies. Planetary consciousness is thus placed in the context of technological changes, which imply both threats and opportunities. We assume that individuals' choices regarding the primary purposes for which they use digital technologies also influence their capacity to develop planetary consciousness. We hypothesise that exploiting the learning potential of digital

technologies is likely to have more empowering effects than their excessive use for gaming and other forms of leisure.

2 Planetary consciousness in the context of modernisation trends

There has been a proliferation of ideas on planetary consciousness in a variety of social domains. Those ideas reflect the claim for structural and a narrative transformation emerging as a response to the devastating effects of the Anthropocene – the era, in which human actions are recognised as essential in influencing the planet. The contemporary perspectives on planetary consciousness often merge scientific, philosophical, ecological, activistic and spiritual perspectives, which can be placed in the context of the modernisation trend of universalism.

While rationalisation (Horkheimer & Adorno, 2007; Weber, 2013), individualisation (Beck et al., 1994; Parsons, 1979), specialisation and structural/functional differentiation (Durkheim, 1997; Luhmann, 1995; Parsons, 1951) have been often emphasised as key aspects of modernisation, a very significant long-term trend of increasing universalism has often been ignored. For its better understanding, we can refer to the classical modernisation theory of Talcott Parsons (Parsons, 1951) who saw it as a prevailing modern alternative to (traditional) particularism in his list of pattern variables. On the top of that, he specified "universal norms" as one of his "evolutionary universals" (Parsons, 1979). For this analysis, we can define universalisation or increasing universalism *as a trend to apply the increasing number of principles that have been applied within the in-group to the increasing number of others* – thus transcending the original in-group.

Unlike the ancient kingdoms and empires, the national "imagined communities" (Anderson, 2016) produced by modernity have mostly transcended the divisions between predominantly particularistic tribal and local communities, or between the (divine or God-given) rulers and their subjects. They produced nation states and their citizens – adhering to broadly the same principles and subordinated to the same "universal norms" (Parsons, 1951). But the modern trend of universalism has not ended with that. It took more than 150 years from "the rights of the man and of the citizen" to granting full human status and corresponding universal principles to all humanity with the Universal Declaration of Human Rights. The latter has established this kind of universalism at a declarative level while clearly remaining an unfinished and on-going project in practice.

Paradoxically, the same (predominantly Western) philosophical tradition that eventually led to unprecedented levels of globalised universalism at the level of humans as species has on the other hand established – perhaps also unprecedented – distance towards nature, especially when compared either to archaic animist or to Eastern religious and philosophical traditions.

Despite their current popularity, the ideas of planetary consciousness are nothing new. Their roots can be found in animistic views on life, while the idea that people are inextricably interwoven with the planet goes back to prehistoric periods. There are many myths, legends, and stories all around the world suggesting the interconnectedness of all living beings, and their reciprocity. In a rather equal distribution of social power within communities, agency was attached to stones, plants, waters, and more etheric beings or spirits of the natural world (Descola & Sahlins, 2014; Šmitek, 2019) – while humans were merely a witness to the all-encompassing flow of energies and identities.

With time, usually coinciding with the advances and socio-cultural patterns brought by the agriculture revolution and permanent settlement, the division between culture and nature has become more emphasised. For instance, in the ancient Greek culture, animistic experience was replaced by theoretical philosophical explanations of reality. The nature spirits became subordinated to the pantheon of gods that became anthropomorphic. Their organisation and interactions between humans and nature reflected the emerging stratification and a hierarchy of social order. The nature presented the domain of the pre-culture, and it was simultaneously the abode of deities (Harvey, 2006).

With established monotheistic religions, such as Christianity, all the numinosity was transferred to the idea of heaven. Natural cycles, deities and spirits were taken over by saints. Sacred sites and landscape geometry was appropriated by sacral buildings of the Church. Earth and its ethereal representations in the forms of fauns or pans became attached to the idea of the Devil. There has been a prevailing narrative, that what exists on Earth is sinful. While God owns everything, the nature is on men's disposal to be used and exploited. One can say that Judeo-Cristian tradition does not support planetary consciousness because divinity was banished from Earth thus asserting nature-divinity dichotomic relation.

The early modern era that followed has been imbued with materialistic values demanding disenchantment and detachment of nature while saying that reality is what you can see, touch, and measure. Already with Humanism and Enlightenment - that offered a bedrock for the modern through – the focus was shifted from God to humans. Those ideas maintained and often even reinforced the separation between civilisation and nature, subordinating the latter to the former. Cartesian dualism proposed that God's creation is divided into two separated realms: a matter that is shaping the natural environment and is subjected to physical laws that can be studied and a mind, which remains in the domain of God. A human has gained a pivotal role in understanding and studying the world surrounding us. The latter was crucial for the emergence of scientific thought and individuals' empowerment, but the condemnation of the nature and its subordination to humans continued. The materialistic view that sees the world as composed from parts has often left people disoriented and in search for a deeper meaning in their lives.

An early contribution to the re-appreciation of the planetary consciousness or even the idea of planetary consciousness has in fact been based on religion – in the idea of all-encompassing love and compassion, which is crucial in supporting planetary entanglement. This is also resonating in the ideas of Teilhard de Chardin, who was not only a scientist but also a priest. He suggested that human awareness was integral to the planet's evolution and it had yet to reach the final stage of consciousness convergence with the Earth. Like many subsequent contributions to this field, his perspective combines philosophical, scientific and spiritual dimensions – in his case derived from Christianity. He contributed to the notion of the noosphere (noos – mind in ancient Greek) that upgrades the concepts of geosphere and biosphere, which has inspired not only philosophical but also contemporary scientific endeavours.

Subsequently, the early modern anthropocentric perspective has become been increasingly undermined by growing interest in ecological movements, social inequality and quality of living, new aspects of spirituality, mindfulness, running away from the materialism and impersonal technologically driven society.

It has been argued (Dennis, 2015) that a spiritual-material worldview can lead to new insights into implications of a coherent conscious universe model for planetary society. Contemporary spiritual movements, including New Age and eco-spirituality are often deeply aligned with ecological and systems-based thinking. These ideas synthesise animistic topics and indigenous practices and find plausible philosophical grounds of and Eastern philosophies, such as Advaita Vedanta and Mahayana Buddhism that emphasize the oneness of life and the environment and see their separation as a distorting illusion (Garrison, 2019). Studies of indigenous sustainability practices across the world (Etchart, 2017; Stein et al., 2022) show a strong connection between planetary consciousness and sustainable, responsible actions and contribute to a vision of the planetary consciousness that entails not only inner transformation but it is also a collective moral imperative.

The reappreciation of indigenous knowledge has been essential in combating the current climate changes and related issues, as we can learn a lot from endorsing their perspectives. They have become relevant for legal and social sciences. The cases of the Ecuadorian and Bolivian Constitutional Chart, in which Mother-Earth is recognized as having, among other features, also a juridical status ('Ecuador First to Grant Nature Constitutional Rights', 2008), or a New Zealand legislation in 2017 (*Te Awa Tupua (Whanganui River Claims Settlement) Act 2017*, 2017) recognizing the Whanganui River as a legal person, are key milestones on which the European scholarship can draw upon. This is also consistent with Latour's position on climate change from the perspective of his Actor Network Theory with the inclusion of non-human actors (Latour, 2007). These processes are very much in line with the potential further expansion of universalistic trends – to recognise some of the universal principles previously reserved for humanity for non-human entities as well.

Recently, there has been a rich and interdisciplinary scholarship on planetary turn and planetary consciousness. For instance, Laszlo's manifesto (Laszlo, 2023), co-authored with prominent figures such as the Dalai Lama, emphasises the significance of transforming individual and collective values to build a sustainable and interconnected planetary community. Inspired by Latour's ideas, Chakrabarty's (Chakrabarty, 2021) argues for the need to distinguish between the global and human centred perspectives on the one hand and the planetary perspectives involving all life on the Earth on the other - seeing the latter as crucial in combating climate challenge. The ideas of planetary well-being has been thoroughly considered in the collection of studies edited by Elo et al. (Elo et al., 2023) combining areas of ecology, ethics, ontology, psychology, and social justice. Linking systemic with spiritual and ethical dimensions, Bentov (Bentov, 1988) and Rockefeller (Rockefeller, 1990) emphasise emphasizing interconnectedness and global ethics, while Naranjo's (Naranjo, 2020) work invites a shift from ego-centric to eco-centric awareness.

An important contribution in attaching planetary scale cognitive activity to other planetary systems, such as atmosphere, hydrosphere, cryosphere and lithosphere, can be found in the work of Vladimir Vernadsky (Frank et al., 2022). His perspectives echo in the contemporary ideas of Gaia hypothesis proposed by James Lovelock (Lovelock, 2005) and further developed by Lynn Margulis , presenting the Earth as a self-regulating, living system. This idea, while initially controversial, has been influential in framing Earth not merely as a passive environment but as an active, responsive entity. Recently, such perspectives have been considered in the astrophysics developing the concept of Earth intelligence by Frank et al. (2022), and cognitive sciences emphasising the idea global brain of the internet and global communication as developed by Peter Russell (Russell, 2008) and upgraded by Francis Heylighen (2013). In recent scholarship, one can find an interesting study by Brodziak et al. (2023) interpreting planetary consciousness as emerging from global networks, interpreting it as an emergent phenomenon analogous to human self-awareness - but on a planetary scale, which is facilitated by technological and social interconnections. All those seminal works hold a common denominator of recognising the integrity of Earth system and the emergent collective intelligence and defying the anthropocentric point of view. Observed from these perspectives, planetary consciousness transcends not only human tribalisms but also anthropocentrism and can thus be understood as the ultimate form of universalism.

The traces of trends of universalism that defies anthropocentric points of view in the contemporary western scholarship, can also be found in a holistic vision on interconnectedness, sustainability, and ecological wisdom by Fritjof Capra (2010). He emphasizes the need for balance and ecological awareness (Tao of Physics), while aiming to build sustainable communities by learning from ecosystems—interconnected communities of plants, animals, and microorganisms. In similar vein, there is an

important legacy of Rachel Carson (2022) revealing the dangers of chemical pesticides, and inspiring environmental consciousness and actions till nowadays. We should also mention Gregory Bateson, who expanded the concept of democracy to include the entire environment, alluring to the meaning of connections among various parts of the universe (Watras, 2015). Those systemic perspectives departed from the classical modern scientific foundations seeing all the natural and social phenomena as machines composed of parts, each having its own functions governed by predictable laws.

Therefore, planetary consciousness has offered a multidimensional framework for rethinking human identity and responsibility on a global scale not only for scholars and scientists, but also for civic actions and spiritual movements. The proliferation of ideas combining systemic thinking, philosophical and spiritual aspirations can be related to the current trends of modernity expressing the combination of unprecedented technological advancements and rapid social structural transformations that has created a cultural environment that is unstable and fragmented, making it difficult for coherent cultural narratives to emerge and take root (M. Archer, 2017).

Planetary consciousness can also be seen as a part of changes, which Grant (2017) defines as a shift toward collectivistic values, and purpose-in-life orientation. In his study, he draws on the Google's digitization of millions of books enabling to access the quantified analysis of culture through the Ngram Viewer (*Google Books Ngram Viewer*)- a massive corpus containing 5,195,769 digitized books or about 4% of all books ever published. Google's Ngram Viewer also indicate the trends in word frequency of planetary consciousness: appearing in the late 19th Century, reaching its first peak between the First and the Second World War and then starting its persistent rise from the movements of the 1960s.

Figure 1: Relative frequency of the phrase "planetary consciousness" and synonymous phrases in the Google corpus of English books from years 1800-2008

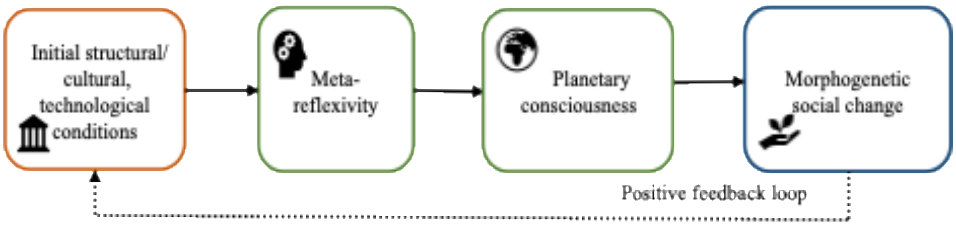
However, while these perspectives have the potential of expanding the trend of universalism and thus mitigate the present challenges (in a similar way as the nation-based citizenship responded to the challenges of early modernisation), a major caution is required. Production of new spiritual movements through uncritical, un-reflected, partly misunderstood older (or imagined) traditions can also be dogmatic, polarising, extremist – adding more fanatical and exclusive echo-chambers to the existing ones. In addition, fixed, isolated and dogmatic beliefs are hardly compatible with the dynamic nature of existing social and technological contexts. Failing to be dynamic and inclusive, approaching planetary consciousness may fall into similar traps as nationalisms, religions and other ideologies before it.

This article therefore merges the planetary consciousness with the particular value orientation and ultimate concerns on the one hand, and the capability for critical reflexive thought on the other – which is seen as a key mechanism in altering social settings (M. S. Archer, 2012) towards broader universalism. While inner dialogues tend to be rational, there is vast scope of emotions that influence individuals' prioritisation of certain issues and concerns and their consideration of alternatives. In the end of this process, some of the concerns are endorsed, while others become subordinated. By exercising reflexivity, individuals can deliberate and mediate upon a greater/deeper understanding of their position within structural and cultural setting, and better evaluate their concerns and resources needed to achieve them.

3 Planetary consciousness and meta-reflexivity: A case study of Slovenia

In the present study, we explore how planetary consciousness is related to individuals' specific mode of reflexivity as proposed by Archer (M. S. Archer, 2003)– namely, meta-reflexivity. With the research, we also intend to demonstrate how this concept can be applied to understanding its practical relevance for human behaviour, as we believe that the concept can serve as a catalyst for cultivating an inclusive social identity. Therefore, forging the identity that transcends divisions such as in-group versus out-group or the dichotomy between society and nature. By fostering a sense of unity that moves beyond harmful exclusionary identities, planetary consciousness is seen as the potential to counteract the rise of fear- and hate-driven identities that fuel political polarization and obstruct rational, democratic decision-making.

Figure 2: A tentative model of morphogenetic social change based on meta-reflexivity and planetary consciousness



This model is based on the morphogenetic approach (M. S. Archer, 1995) analytically disentangling social structure, culture and agency thus seeing every social outcome as an effect of their interplay. Morphogenesis occurs when agents elaborate on social/cultural context and consider their intentions and future concerns through reflexive internal conversation (M. S. Archer, 2003). Firstly, there are the initial structural conditions (institutional framework, individual's position in social structure and social relations) and cultural conditions (values, norms, beliefs, ideologies and other cultural artefacts), in which individuals are settled. Individuals elaborate on these initial conditions through reflexive thinking, which paves grounds for intentional action. The study assumes that meta-reflexivity influences the intensity of planetary consciousness, which can lead to the actions oriented towards social change embracing planetary turn.

Building on the theoretical foundations elaborated above, we propose the following hypotheses that guide our empirical study:
H1: Planetary consciousness can be operationalised and empirically observed as a unidimensional phenomenon.
H2: More meta-reflexive people are more likely to exercise higher level of planetary consciousness.
H3: Planetary consciousness is affected by the ways how people interact with digital technologies.
H4: Demographic features place people in different structural positions thus affecting their planetary consciousness.

While our research is based on the national case study it nevertheless reflects some wider trends in Europe and world-wide, as Slovenia can be comparable to several other EU countries. Being geopolitically positioned at the crossroads between the central, southeastern and Mediterranean parts of Europe, Slovenia is subject to a variety of socio-cultural influences from these regions—making it, at least to some extent, representative of the broader European variety despite its comparatively small size. Secondly, it is a case study exemplifying rapid social change. As a European post-communist country, it has experienced a quick shift from a comparatively predictable social environment,

maintained through communist rule, to sudden exposure to global neo-liberal pressures (Golob & Makarovič, 2017). Thirdly, in terms of development, it is close to the middle: between the more developed, established EU member countries, and the developing new European democracies. Among the former communist countries, it is particularly interesting because of its good starting position at the beginning of the democratic and market reforms (Crowley & Stanojević, 2011) and a comparatively successful transformation, integrating it into the wider European environment. This can be illustrated by the fact that Slovenia has been the first among the new member states that joined Europe in 2004 to adopt the Euro. Finally, it does not stand out in terms of sustainability when placed in the European perspective. While its precise positioning varies significantly depending on the criteria, it is mostly close to the European Union average.

4 Materials and methods

Our empirical study is based on the social survey on the Slovenian representative national sample of 908 adults. It was conducted between 4th and 12th of March 2024 using computer aided telephone interviewing (CATI) method.

We operationalise the concept of planetary consciousness for the use in a social survey questionnaire as a combination of three aspects, expressed through the three corresponding statements on "how much this is true for you personally" providing 6-level Likert scale-responses ranging from "not true at all" to "completely true":

- connectedness in a cosmopolitan sense going beyond belonging to specific groups of people: "you feel strongly connected to all people in the world"
- connectedness beyond anthropocentrism involving other living beings: "you feel strongly connected to all animals and plants in the world" and
- explicit feeling of oneness with the planet: "I feel to be one with the whole planet".

To assess individuals' meta-reflexivity, we have applied RMT question battery consisting of five questions as a proxy for reflexivity levels ranging from 0 (no reflexivity) to 20 (full reflexivity). The RMT has been explained more in detail and tested in our previous research (Golob et al., 2021; Golob & Makarovič, 2019). For this paper, we just briefly summarise that the items included in this scale consists of assessing the frequency of the following behaviours:

- plan your own future
- rehearse what you would say in an important conversation
- imagine the best and worst consequences of a major decision
- review a conversation that ended badly
- clarify thoughts about some issue, person or problem.

The second part of the RMT questions battery provides the proxy quantitative scores for the reflexivity modes, such as meta-reflexivity. The scores for the reflexivity mode range from 0 (minimum) to 80 (maximum score) and are calculated as a combination of reflexivity levels with the Likert-scale responses regarding the reported frequency of "considering the key priorities of your life and why you are doing what you are doing". We have also included the questions regarding the extent of using "computers, smartphones and other digital technologies for "social networks (e.g. facebook, instagram, whatsapp, twitter)", "playing videogames", "your work or formal education" and "informal learning and following the news". For each of these items, the respondents specified the numbers of daily hours.

Demographic features including gender, age, educational level, settlement type and income have been included as well.

5 Results

The responses to the questions referring to the three aspects of planetary consciousness – related to humanity, other living beings and the whole planet – are presented in Table 1. It is worth noting that for all aspects, majorities from 60 to 72 per cent are closer to fully attributing these statements to themselves than to fully rejecting them. Moreover, for all statements the percentage of respondents fully accepting the claim is higher than the share fully rejecting it. The most broadly acceptable claim is the one referring to the connection with the animals and plants. This may even indicate some kind of post-anthropocentric shift or deep divisions within humanity – as it feels easier to connect with other living beings than with "all people in the world". Feeling one with the planet makes people more divided than the other two issues – with the comparatively highest prevalences of people either fully rejecting or fully accepting the notion – and thus standing out in terms of the highest standard deviation.

Table 1: The presence of the aspects of planetary consciousness in the Slovenian national sample

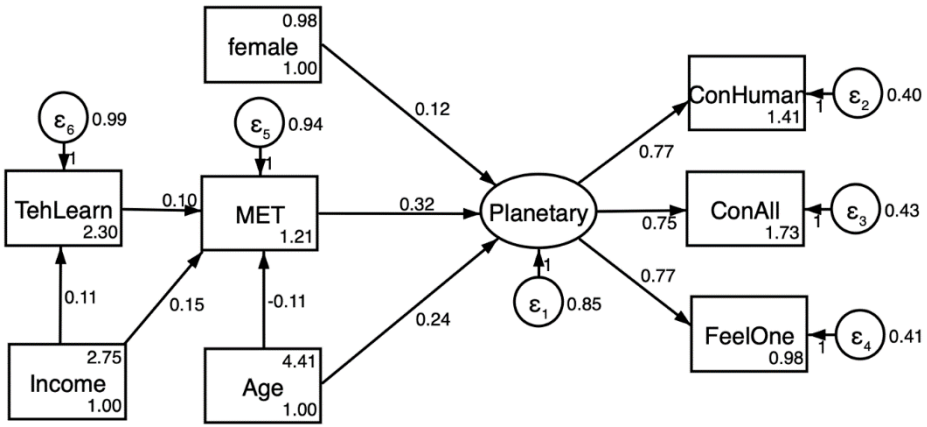
How much this is true for you personally…	Feel strongly connected to all people in the world	Feel strongly connected to all animals and plants in the world	Feel to be one with the whole planet
0 (Not true at all)	9.19	7.12	17.03
1	11.69	7.62	9.14
2	19.36	12.83	14.06
3	30.78	29.96	24.23
4	17.22	23.89	16.00
5 (Completely true)	11.77	18.59	19.54
Total	100.00	100.00	100.00
Mean	2.70	3.12	2.68
Std. deviation	1.43	1.43	1.68

Source: Own research and calculations.
Note: Relative frequencies and means are weighted (post-stratified) to match the structure of general Slovenian national population in terms of gender, educational level, age and settlement size. Nonresponses and "don't know" responses are omitted from the analysis.

Our further analysis shows that despite these differences the three aspects of planetary consciousness are highly correlated with each other and are clear indications of a single latent variable behind all of them. Their Cronbach Alpha equals 0.7976 and principal component analysis provides a clear one-dimensional solution with the single component explaining 71% of the total variance. This confirms H1 that planetary consciousness can be operationalised and empirically observed as a unidimensional phenomenon. This also allows us to operate with planetary consciousness as a latent variable in our subsequent analyses.

Using structural equation modelling, we test hypothesis H2 on the effects of meta-reflexivity to planetary consciousness, while controlling for the effects of the intensity of using digital technologies for different purposes (referring to hypothesis H3) and demographic features (referring to H4). After testing and discarding the insignificant effects, our model of the impact of meta-reflexivity to the latent variable of planetary consciousness, we develop the structural equation model presented in Figure 2. The effects of exogeneous variables to the endogenous ones are mutually comparable as they are reported in terms of standardised regression coefficients.

Figure 3: Structural equation model of the effects of meta-reflexivity, digital technology and demographic features to the latent variable of planetary consciousness



The model indicates a good fit. It is close to the saturated model (chi-square significance equals 0.186). Root mean squared error of approximation equals 0.020 with the 99.2% probability of not exceeding the threshold of 0.05. Comparative fit index equals 0.995 and Tucker-Lewis index is 0.992. Standardized root mean squared residual equals 0.02. The model, however, explains 15% of the variance of the planetary consciousness latent variable, demonstrating that quite significant variance of this complex concept remains unexplained.

We can confirm hypothesis H2, as meta-reflexivity (variable MET in Figure 2) turns out to be the single most important variable affecting the constructed Planetary consciousness variable. People demonstrating higher meta-reflexivity scores are significantly more likely to report higher levels of planetary consciousness.

We cannot confirm hypothesis H3 regarding the direct effects of the use of digital technologies (variable TehLearn) to planetary consciousness. No aspect of using digital technologies had the statistically significant effect that would go beyond the allowed 5% risk of obtaining our results with the corresponding beta coefficient being zero. We may suspect the existence of a slightly negative effect to planetary consciousness by extensive use of digital technologies for work or study, but the significance for the coefficient only resides with the 10%, i.e. not within the usually accepted 5% threshold. However, the extend of using digital technologies for informal learning and following the news has a positive effect on meta-reflexivity scores and – through them – indirectly contributing to greater planetary consciousness.

We can partly confirm hypothesis H4 – as far as it refers to the effects of age and gender. The effects of age are not straightforward. Younger people tend to be more meta-reflexive than older people: this way, being younger indirectly positively contributes to planetary consciousness through increased meta-reflexivity. However, when these effects are controlled for in our model, it turns out that the older people tend to report higher planetary consciousness. In other words, the youth is more likely to be meta-reflexive and – through that – also more inclined towards planetary consciousness. But when a young person in not meta-reflexive, she or he, would be less likely to express planetary consciousness than an older person.

Finally, women are more likely to express planetary consciousness than men. While the direct effect of gender is relatively smaller when compared to meta-reflexivity and age, it is still clearly statistically significant.

In addition, we should note another indirect effect – of income. While income levels have no direct statistically significant effect on planetary consciousness, they positively contribute to the probability of using digital technology for informal learning and following the news (which contributes to meta-reflexivity) and to meta-reflexivity itself (which contributes to planetary consciousness). In other words, though these effects are only indirect, more well-off people are in a better position to develop planetary consciousness.

In our analysis, we have also tested the possible effects of educational levels and settlement type, but they have turned out to be statistically insignificant. The same is true for all the other uses of digital technologies, i.e. for playing games and social networking.

6 Discussion

Planetary consciousness as a concept and value orientation offers a multidimensional framework for rethinking human identity and responsibility on a global scale. It connects various perspective, disciplines, and cultures, and it can serve as a compass—orienting humanity toward cooperation, humility, and respect for life in an interconnected world.

It is a concept that can challenge dominant anthropocentric and exclusivist perspective, legitimise responsible behaviour on individual level and transformative global policies on the macro level. These specific value orientations contain ideas that can glue human society together, transcend separations between humans, other beings, and the planet itself – thus bringing us back to the essence of being: to the core of the unconscious, emotional, instinctive existence, and back again – to the rational, reflexive thought.

In a world marked by rapid and unpredictable change, the mode of meta-reflexivity, is at the heart of shaping a sense of self and constructing a social identity. Based on critical inner dialogues, individuals can critically re-valuate the existing social setting and adopt specific 'stances' towards society enabling them to form ideas of favourable environments: natural, social or technological. This constitutes the micro-macro link referring to the 'active agent' (Archer, 2003), who is striving for social change to occur. In that regard, meta-reflexivity can contribute to new social formations based on morphogenetic processes in society. By exercising meta-reflexivity, individuals can deliberate and mediate upon a greater/deeper understanding of their positions within structural and cultural setting, and better evaluate their concerns and resources needed to achieve them.

Meta-reflexivity requires a driving ultimate concern referring to certain cultural ideal, which is fuelling individuals' deliberations and actions towards concrete social and environmental challenges. For this purpose, it is essential to become aware of the planetary interdependence and coexistence of all parts in the Earth's system - in which humans act as emergent entities with their own causal powers. Seeing humans as the integrative part of the biosphere and its planetary intelligence, we could also actively contribute towards better and more sustainable life on Earth – as we are emergent biological bodies and self-aware beings. In that regard, people can act altruistically not only within the existing social groups, to which they belong (Aronson et al., 2015; Tajfel et al., 1971), but in a wider planetary context.

It is therefore of great importance that we become aware of the need of new paradigmatic grounds defining our value orientation that emphasise that if we are not going to fundamentally change the ways of production, consumption and the underlying norms and values legitimizing social actions, our civilization – not the Earth itself – will cease. Our study shows that meta-reflexivity works as a precondition for new social practices on individual and collective level toward sustainability and planetary consciousness. However, meta-reflexivity is also conditioned by other factors, such as social embeddedness, which affects directly also the planetary consciousness. It is a great challenge how to activate and nourish planetary consciousness in the world of ever deepening economic disparities, ideological polarisation, and how to increase meta-reflexivity in that regard. One of the strategies could be in systematically incorporating both, the planetary consciousness and critical thinking into the strategic developmental document, school curricula, research projects, business models and civic initiatives.

It is crucial for these strategies and policies to be broadly inclusive. People who are – or feel to be – left behind, who experience increased relative deprivation, are less likely to be reflexive, but more likely to develop radical and polarising attitudes and to follow authoritarian and populist leaders. Individuals and groups that feel excluded may compensate their feelings of deprivation through supporting exclusion of other (even

more) marginalised groups; they might also care less for the well-being of other living beings in general. Confronting one's own grievances by attacking and blaming "the other" has been a very common historical phenomenon. Combining that with re-inventing mythological narratives based on exclusion and lacking meta-reflexivity is prevalent as well.

These challenges imply that the struggle for planetary consciousness would have no perspective as an elitist project that looks down on the "unaware" masses and ignores the sources of their deprivation. It can only succeed as a combination of inclusive, compassionate, grassroots movement on the one hand and policies that systematically address all types of economic, social and cultural deprivation, on the other hand.

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Part II

Bottom-up Knowledge and Learning for European Industry 5.0

The Role of Scientific Knowledge in Local Sustainable Practices: Addressing the Challenging Relationship between Science, Politics and Public

MARUŠA GORIŠEK [1]

Abstract This chapter examines the use of scientific knowledge for sustainable development at the local level, emphasizing the relationships between science, politics, and the public. While science and technological innovation offer solutions to global challenges, including climate change, their application depends on effective collaboration and public trust. Drawing on literature and selected case studies the chapter explores how local governments and communities engage with scientific knowledge through policymaking, deliberative initiatives, and citizen science. It identifies limitations in knowledge utilization, evaluates collaboration between actors, and highlights local initiatives' potential to bridge gaps between science and society for a more sustainable future.

Keywords: • science-politics-public relationship • sustainable development • local sustainable practices • deliberative democracy

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https://doi.org/10.4335/2026.2.3 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

The aim of ensuring sustainable development has been in the forefront of political and public discourse in the last decades. It envisions growth without harming opportunities for future generations with special emphasis on social and environmental dimensions. The United Nations points out that science is *''at the heart of sustainable development. It establishes the factual basis, anticipates future consequences, and contributes to finding pathways to sustainability transformations''* (United Nations, 2019, p. 111). As such science can provide advice for policymaking. Furthermore, technological innovation can lead to solutions that enable more sustainable practices and address some of the most pressing challenges of our society, such as global warming and its consequences.

These challenges, although global in their nature, are increasingly affecting local communities. On the one hand, local communities are often the ones dealing with the consequences of severe weather disasters caused by the environmental changes, especially on the infrastructure. On the other hand, local communities are the source of community-driven actions towards a more resilient and sustainable society focusing on the local ecosystem (United Nations Development Programme, 2012). This was recognized already in 1990s where Agenda 21 predicted that every local government should create its own Agenda 21 for sustainable development (United Nations Conference on Environment and Development, 2010). Consequently the focus on local sustainable development has been gaining importance in research (Milán-García, Uribe-Toril, Ruiz-Real, & de Pablo Valenciano, 2019).

Recent global pandemic showed that there are several limitations in using scientific knowledge for the greater benefit of the society. Despite fast technological and scientific progress management of the pandemic remained challenging. Strong groups refusing scientifically based advice and explanations formed all around the globe (Adam & Gorišek, 2022). It became even more evident that utilization of scientific knowledge for public good depends on the complex set of relationships between science, politics, and the general public.

In the last decades several authors observed that scientifically produced knowledge is becoming less and less valued (Collins, 2014; Nichols, 2019). On the one hand we are dealing with the question of how scientific advice should be used in political process. In contemporary societies policymakers rely on experts and scientists through a complex network of advisory boards, expert groups and other consultations. During the pandemic we often heard appeals for politics to just *follow the science*, however, political process requires deliberation and search for consensus (Lavazza & Farina, 2020). Complexity of our reality means that it is not easy to translate scientific explanations of the world into straightforward guidance for government action (Stevens, 2020). On the other hand, the general attitudes of people to science have been changing. Nichols (2019) describes the

increasingly common contempt for expert opinion as a way of establishing one's own autonomy. With universally available information, it is easy for individuals to feel like they themselves are also involved in scientific processes and that each opinion is equally relevant (Collins, 2014, p. 16).

The obstacles in utilizing scientific knowledge for public benefit are thus multifaced and complex. They mostly revolve around roles and relationships of different actors. This chapter observes how scientific knowledge is used for sustainable development on local level while focusing on the relationships between science (and experts), politics and general public. We address the following questions:

- Which are the main limitations in utilization of scientific knowledge on local level?
- How does focusing on sustainable development fuel collaboration between scientists, politicians and public on local level?
- Which kind of local initiatives can help bridging the gap between science, politics and public?

These questions stem from observations of several sustainable development projects and initiatives that emerged on the local level. We discuss them from the perspective of actors' relationships and evaluate the potential they hold for addressing some of the more global challenges related to the use of scientific knowledge and creating a sustainable future. The first part of the chapter is based on the analysis of the literature and observes the relationships between science, politics and general public. Special attention is given to the role of scientific knowledge in sustainable development and the uses of scientific knowledge on local level. In the second part, the article focuses on the empirical evidence to address the research questions. This is done on two levels. First, we discuss the collaboration between local politics and science. On the basis of case studies from Europe, and especially Slovenia, we first observe how focusing on sustainable development indeed promoted more collaboration between scientists and local politics. Second, we focus on the relationship between science and citizens in local communities. Here we observe case studies of deliberative initiatives and examples of citizen science projects and discuss the potential they hold for bridging the gap between science and public. Building on these observations, the chapter discusses deliberative local practices as a potential for enhanced cooperation between experts, local politics and the public.

2 Complex relationships between science, politics and public

Modern societies are very complex and functionally differentiated. In this context, no scientific discipline alone can encompass all aspects of reality, and even less so are we individuals capable of doing so. Societies have become too complex even for governments and decision-makers, and thus virtually all political spheres have become dependent on the input of experts. Politicians and decision-makers must consider different

aspects of a problem when making decisions, e.g. environmental, social, political and economic.

In modern democracies, the tendency towards greater inclusion of science and experts in political processes is also captured in the idea of evidence-based policy making, which strives for greater rationality, systematicity and reliance on objective evidence in public policy processes. In practice, politicians most often rely on science and scientific knowledge through a complex network of advisory bodies and institutions, committees, hired experts and think tanks (Knight, 2019). These are established on different levels, from partisan, local, to national and even international ones. They combine expert advice and political action, as the appointment of members to individual bodies is often a matter of political debate, which can affect the way they operate and the quality of expertise. Choi et al. (2005) point out that scientists and politicians have different goals and attitudes towards information, speak different languages, and have different perception of time.

While politicians usually strive for fast, visible results, scientific process is long and ever changing. In political process, science is often understood in oversimplistic manner as a unified and consensual system that produces indisputable truths. This fails to recognize the actual complexity of the scientific process, which involves disagreements and debates as essential components of progress. Furthermore, scientific or expert advice does not mean a unanimous fact as experts and scientists often disagree between each other.

On the one hand, different disciplines can reach different conclusions based on the same data (Knight, 2019) but even within the same discipline there are disagreements on certain topics. The advice of experts is not always technical and neutral and often holds strong axiological implications. The opinions and recommendations of experts during the pandemic often go beyond just finding the best technical solution and interfere with certain key human values (Lavazza & Farina, 2020). However, they point out that this is not only a simple question of translating scientific evidence in action. While scientific facts can describe the problem and offer options, it cannot make decisions on behalf of society. In this sense, leaving the decision-making to experts would be impractical and immoral (Willis, Curato, & Smith, 2022). This shows that exaggerated emphasis on politicians following the science, as was often observed during the pandemic, might be used by politicians to avoid blame and shift responsibility and accountability to scientists and experts (MacAulay, Fafard, Cassola, & Palkovits, 2023).

Nevertheless, experts and scientists are themselves a part of social and political process with their own values and political preferences and can follow specific ideologies and interests. While this represents a kind of obstacle to recognizing the legitimacy of experts, public attitudes still distinguish between politics on the one hand, which acts biasedly and within the framework of interests, and experts, who have a non-political function of

finding the best possible solution to problems, ideologically unencumbered and without political prejudices (Stehr & Grundmann, 2014, p. 105).

2.1 Science, politics and public on local level

Political decision-making differs on national and local level. While on the national level politicians deal with country-wide issues such as national welfare, security issues and larger policy frameworks, local politics are more specifically oriented in concerns regarding living in the area, such as providing infrastructure and services to the needs of the community. In this sense they are often more pragmatic and less ideologically charged. National and international level set a legal framework in which local politics acts. It is often considered that local politics are closer to citizens, rely more on citizen participation and take their needs in consideration more directly. Eurobarometer studies also show that citizens trust local governments considerably more than national or EU level of government (Arrighi et al., 2022).

Similarly to this, the role of science differs on national and local level as well. Especially because of the practical orientation, the use of science is in local context more often linked to the actual local problems, local cooperation networks and practical outcomes, and less likely for strategic orientations and structured scientific advisory processes. This might give a false impression, that scientific advice is not present at local policy-making level. Since there are often less structures, such as advisory boards and scientific expert groups, formed at local level, scientific knowledge is still included in local level politics (Mason, 2016). Lundin and Öberg (2014) analyse the case of Swedish local politics when addressing how public administrators use expert knowledge when preparing policy advice. They find out that expert advice is more likely used in cases where either political dispute or public attention is high.

Combating climate changes without a doubt belongs to these categories and demands scientific input in political process. Willis et al. (2022) count the way in which technical, scientific and expert advice are used in political process as one of the main reasons for the failure of addressing climate crisis. It is not only a lack of translating scientific facts to the policymaking, but a lack of proper cooperation and dialogue between actors. Richards (2019) points out the need for true science-policy co-production for concrete mutual influence. This includes being open to broad discussion with accepting each other's feedback, identifying and resolving disagreements and holding one another accountable. These so-called science-policy partnerships can more easily be established at municipal or local level of government, especially in the case of climate changes. There are several reasons for this. As mentioned before, municipalities are often the ones dealing with adaptation and recovery measures for several immediate and concrete impacts of climate change, especially in infrastructure. Furthermore, municipal governments are often smaller and less formalized compared to the national ones and often under less

public scrutiny which can make new interactions and initiatives more likely to form (G. Richards, 2018).

However, the way in which scientific advice is used in society does not depend only on the extend to which scientific advice is included in policy process. The way public perceives these advices and how they react to them is equally important. Collins (2014) explains that the public attitudes towards science and experts changed significantly in recent decades. The knowledge produced by scientists is becoming less valued. Nichols (2019) adds that experts no longer have real value in society and that society believes that every opinion is equally valuable. The authors cite several reasons for this change in relationships. On the one hand, it is a kind of empowerment of the individual – despising expert opinion means a kind of establishment of one's own autonomy. With the widespread availability of information and the awareness that science is also fallible, there has been a stronger sense in society that every individual is part of the scientific process and that every individual has the right to an opinion that is equivalent to an expert opinion (Collins, 2014: 16). Furthermore, many individuals see experts as members of political elite and grow similar dissatisfaction and distrust in them.

We are thus dealing with a situation where people are more and more dependent on experts and their advice without establishing dialogue between the two sides. On the one hand, dialogue is rejected by citizens with a negative attitude towards experts, and on the other hand, many experts, especially those from the academic and scientific spheres, completely neglect this task and do not actively engage in greater communication with the public (Nichols 2019). The scientific community often sees laypeople as uneducated and unqualified to discuss scientific matters and that discussion of science should only take place within the scientific sphere. Laypeople do not understand science for the most part, but as Knight (2019) explains, scientists too often ignore or reject the weighty points of the public or laypeople in their work. Furthermore, there are important problems within scientific field as well, that influence public perception of science. For example, a crisis of reproducibility of research, publish or perish concept (De Rond & Miller, 2005), overhyping research findings, predatory publishing and citation misdirection (West & Bergstrom, 2021).

The concept of Open Science is intended to target several of these challenges. The beginnings of the open science movement were largely focused on open access to scientific publications, data, and software. Several authors speak about the benefits of such data openness, like enabling diverse data analysis, verifying existing results, generating new knowledge, and promoting interdisciplinarity (Uhlir & Schröder, 2007). Already nearly 20 years ago, Eysenbach (2006) noted that open-access scientific publications offer advantages in terms of citation rates, accessibility to relevant actors (user uptake advantage), and the promotion of connections between disciplines (cross-disciplinary fertilisation). This encouraged investments to develop data-sharing platforms

such as the European Open Science Cloud (European Research Area), a stronger focus on data management planning, and national (and supranational) guidelines for open access and open science. Nowadays, open science is not just a recommendation, but a mandate in many European countries that have included it in the national legislation. The goal of open science is no longer to merely enable open access to research data, but to assure the participation of the public in science (citizen science) and renovate the criteria for evaluating scientific performance. While this approach is targeted to ensure greater cooperation between science and general public, it focuses only on the openness of science without taking into account the complexity of the scientific process, relationships between different actors and the problems within science that influence them, such as narrow specializations, lack of interdisciplinary cooperation or conflicting opinions within science.

The concentration on the over-simplified idea of trust in science as opposed to a more complex understanding of public attitudes to science has several other problems as well. On one side, they presume that people's reported attitudes to science predict their behaviour. Au et al. (2024) warn that those who report low levels of trust can still take medicine and follow medical experts' advice. On the other side, through a series of experiments O'Brien, Palmer and Albarracin (2021) find that people with a higher level of trust in science can be more vulnerable to misinformation containing pseudoscientific content. They explain that the sole presence of scientific labels (like the name of an institution or credentials of an "expert") makes them believe the information and also likely to share it with other people. The authors argue that more than trust in science, the methodological literacy and ability to critically and systematically process information impact people's resilience to pseudoscience and misinformation.

3 Sustainable development as a catalyst for cooperation

As mentioned in the previous chapter, municipalities are often directly involved in sustainability challenges through infrastructure and services management. Ensuring resilient and sustainable practices require multi-stakeholder approach with knowledge-based policymaking. As such, sustainable development can also be understood as a policy framework which encourages cooperation between municipalities and different stakeholders, including scientific and academic institutions. This often takes place through joint projects and initiatives supported by national, regional or international funding schemas. In this chapter we first explore how these projects can encourage cooperation between science, politics and general public in two ways. First, we address the question whether global focus on sustainable development emphasizes and advances cooperation between local authorities and scientific organizations, and with this the use of scientific knowledge in public policy process. Second, we observe how local initiatives and projects that support citizen science and other similar participatory scientific practices help bridge the gap between science and public.

3.1 New framework for policy-science intersect

Global focus on sustainable development resulted in many legal and strategic frameworks which influenced local policymaking. Already in 1990s, following the UN's Agenda 21, local communities were expected to adopt their own Local Agendas 21, a plan for sustainable development. These were mostly focused on the environmental aspect of sustainable development, and while putting emphasis on stakeholder cooperation and engagement, they often excluded scientific and academic actors and focused on cooperation with local inhabitants, organizations and private enterprises ('DSD :: Resources - Publications - Core Publications', n.d.). It was in later documents and strategic plans that the important role of science in the process of sustainable development was emphasized. In last few decades, several EU, international and national programs were established which promote partnership between local authorities, stakeholders and academic institutions. This led to more project-based cooperation through grant-funded projects. In this chapter we focus on the case-study of Association of Municipalities and towns of Slovenia (SOS) which is the biggest representative association of municipalities in Slovenia, covering more than 90% of the municipalities.

Since 2008 SOS took part in 27 different national and international projects. Out of these, 21 were directly connected to one of the 17 Sustainable Development Goals and other 6 were at least indirectly connected to them as well. Most commonly they dealt with sustainable energy and energy efficiency, circular economy, inclusion and lately climate change adaptation and preparedness. In observed projects 18 of them directly included cooperation with academic organizations, meaning that either a university of research institute was part of the consortium conducting the project. In three projects, scientific knowledge was indirectly involved through think-thank type of NGOs or external experts that were involved in the project. The remaining 6 projects were mostly oriented towards municipalities networks and peer-to-peer collaboration. Here, we present two case studies of interdisciplinary projects, one national and one international, aimed at achieving greater sustainable development. The cases were chosen as a good practice example because they showcase how sustainable development can serve as a framework for cooperation between science and local authorities.

Project LIFE4ADAPT is a strategic integrated national project funded by the European programme LIFE through the Slovenian Ministry for Environment, Climate and Energy. It joins 19 partners from science, administration, NGOs and local authorities with the main goal to increase climate change preparedness through cooperation, knowledge and action on all administration levels. Other than raising awareness, the project intends to conduct pilot projects in the areas of farming, forestry, nature preservation, health and water management. Furthermore, the project intends to create educational programmes for teachers, students and experts, aimed at the transfer of knowledge in practice.

3.2 Local knowledge in scientific research: participatory and citizen science

The discussions regarding the role of science in society often highlights the gap between scientists and general public. It is often considered that the process of scientific research is the domain of scientists, who work far away from lay public, which does not understand science. Recent open science movements address this gap through promoting participatory and citizen science research. These approaches are especially relevant for local communities and show considerable potential in the field of sustainable development.

The term citizen science refers to the inclusion of non-scientists in scientific process. Early definitions describe citizen science as the participation of non-scientists in the process of gathering data according to specific scientific protocols and data interpretation as well as in the decision-making on policy issues with technical or scientific components and engagement of research scientists in democratic and policy processes (Lewenstein, 2004). More modern approaches refer mostly to the scientific process where non-scientists can take up different roles. The European Citizen Science Association states that even minimal participation, such as downloading an app that automatically collects data, can count as citizen science if "if it aligns with 10 principles or supports the production of scientific results that would not have been possible without the informed decision of volunteers to contribute" (Haklay et al., 2020).

Although similar concepts have been long recognized in social sciences research (for example participatory action research, see (Lewin, 1946), citizen science gained considerable popularity in recent years, being vastly promoted "as a recognized, promoted and funded approach, which fosters scientific literacy and the democratization of science" (ESCA.ngo, 2023). Such participatory projects should benefit both sides of the coin. On the one hand they increase citizens' understanding of scientific process, educate them in specific fields and empower citizens to actively participate in society. On the other hand, these projects are aimed at enriching science or the otherwise narrow expert scientific point of view. In this sense they hold great potential for research connected to sustainable development.

The United Nations Environment programme (2019) point out that citizen science enables researchers to include large numbers of individuals in data collection phase, which can help monitor the sustainable development goals and improve community awareness and action. Fraisl et al. (2020) note that citizen science is already contributing to the monitoring of five sustainable development goals, and could contribute to many more, especially in the areas *Life on Land, Sustainable Cities and Communities, Good Health and Wellbeing* and *Clean Water and Sanitation.*

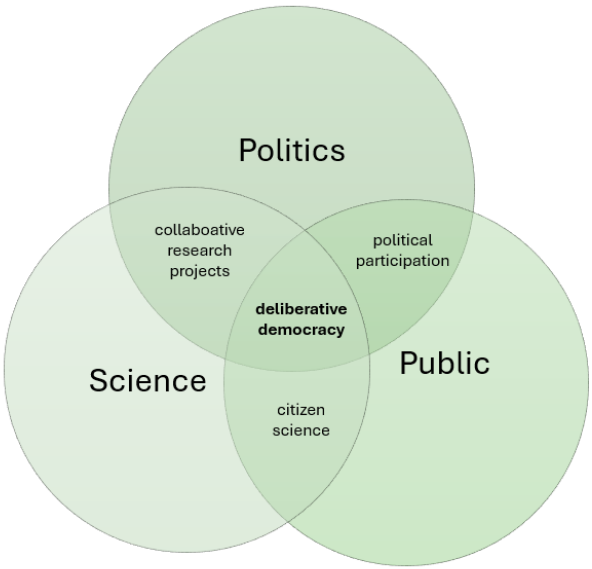
Citizen science projects can also promote community-based data collection. For example, a participatory project in Brazil involved local community groups in mapping and managing risks of natural disasters and identifying changes in landscape, risk areas and disaster events. The authors report the learning benefits for both, involved members of the community and the scientific team on the effects of extreme weather events in their territories. This approach enabled integration of knowledge from different systems – local and scientific knowledge (Albagli & Iwama, 2022). Ijatuyi and others (2025) speak of importance of including indigenous knowledge in scientific knowledge. This is knowledge rooted in cultural and environmental context of indigenous people and is mostly tied to land use, ecosystems and sustainable practices. Several authors (Naess, 2013; Reyes-García et al., 2016) and institutions point out the importance of local knowledge in addressing climate change and adaptation to climate change.

Researchers have discovered that participative and citizen science projects hold wider societal implications in terms of direct practical effect (King, Winter, Chrisinger, Hua, & Banchoff, 2019), the more applied orientation of projects and influence the democratisation of science (Sauermann et al., 2020).

4 Local communities as areas of deliberative democracy

The relationships between science, politics and public are complex and multifaced even on local level. Based on the previous chapter we can see different arenas where these three spheres meet. This is shown in figure 1. However, each of these intersections has limitations. Collaborative scientific projects that establish cooperation between scientists and politics often lack involvement of public and have limited policy implications. Similarly, citizen science projects often stay on the level of research without including local political actors in them. In the search of activities that would ensure cooperation between all three spheres, we look at the deliberative local practices as a potential solution.

Figure 1: Visual representation of intersections between the spheres of politics, science and public



Deliberative democracy shares features with direct democracy of citizens and goes a step further than the types of direct democracy that are already embedded in modern liberal democracies, such as civil initiatives or referendums. It is a model of political and social relations where legitimacy derives from extensive public debate (Pinter, 2004). Individuals should not be seen merely as passive subjects of legislation, but as autonomous agents who are actively involved in the governance of their society (Gutmann & Thompson, 2004). Deliberation therefore involves more than simply expressing individual preferences and values, and is based on more complex communication in which opinions are weighed and transformed on the basis of logic and reason. One of the key proponents of deliberative democracy is Jürgen Habermas, who bases his argument on the idea of popular sovereignty, whereby the key source of legitimacy is collective judgment. This theoretical foundation also has practical implications, particularly at the local level.

In its essence, local self-government is a form of exercising citizen self-management and gives residents the right to manage local affairs themselves (Brezovšek, 2009). This idea is also embodied in the concept of deliberative democracy. It refers to the idea of policymaking and political decision-making in which the public plays a key role,

participating in the political process through deliberation—that is, through discussion and the confrontation of different opinions and perspectives—formulating proposals and alternatives and voting on them.

Despite its broad theoretical scope, deliberative democracy is often applied more modestly in practice. Besides the organizational challenges of such activities, the authors also point out other dilemmas, such as the question of who participates in these activities, how the process itself unfolds, how the results are influenced by the dynamics of each group, and how the products of deliberation are subsequently integrated into the political decision-making process (Ryfe, 2005).

Among these dilemmas, perhaps the most significant concerns the role of knowledge in such decisions. As mentioned, the involvement of science and experts in political decision-making is a consequence of the increasing complexity of modern societies and the issues that governments must decide upon. If a government needs the help of experts because it cannot make decisions on such complex matters alone, is it then reasonable to expect that citizens will be able to do so? Somin (2010) explains that the concept of deliberative democracy assumes that participating citizens possess two types of knowledge – factual knowledge about a particular topic and an understanding of moral and philosophical arguments. In the deliberation process, it is not enough for citizens to simply have their opinions and preferences on certain issues; they are also expected to defend and discuss them in an informed manner, with detailed arguments.

Given these challenges, especially those related to knowledge it is unrealistic to expect deliberative democracy to serve as the primary model for policymaking and political decision-making, the principles of deliberative democracy can be actively incorporated into narrower and more specific contexts in various forms, such as deliberative workshops and discussions.

Recent research illustrates this point. Willis et al. (2022) argue that a deliberative approach offers an opportunity for better reaction to climate change, as it still regards scientific and technical evidence while also recognizing the value of knowledge of different actors, as well as ethical and moral positions. They describe two case-studies of deliberative mini-publics, one in UK and one in France. In both cases, scientific advice was part of the process. A learning phase was included, where independent advisory group chose evidence and witnesses that the participants were exposed to before deliberation (Willis et al., 2022).

More broadly, deliberative democracy encompasses a variety of formats. Ayano (2021), for example, mentions consensus conferences, deliberative polling, citizens' juries, and planning cells. In Europe, there are also several practical examples of incorporating deliberative democracy into decision-making at the local level. The report of the Congress

of Local and Regional Authorities of the Council of Europe, for instance, cites examples such as a citizens' contact group or forum in the Belgian rural community of Oud-Heverlee, which developed proposals on water management; the Scottish Citizens' Assembly on Climate Change; and the German-speaking community of Ostbelgien in Belgium, which has developed its own model of deliberative democracy and integrated it into its institutional framework (Congress of Local and Regional Authorities, 2022).

However, the success of such deliberative practices depends on the planning and implementation. The Congress of Local and Regional Authorities (2022) outlines several principles of deliberative processes that municipalities should consider when introducing deliberation into policy-making procedures. Key principles include clearly predetermined and communicated ways in which the result of deliberation will be used in the political process, careful definition of how participants are selected and how who determines the agenda. Organizing the process also involves preparing facilities, staff, materials, and compensating participants. Transparency, impartial and understandable informational materials, and skilled moderation are essential to ensure equal participation and reasoned discussion, with input from science enhancing the quality of deliberation. The success of deliberative processes can be measured using the OECD framework, which highlights the integrity of design, the quality of deliberation, the influence of proposals on decision-making, and the broader impact on public attitudes (Gastil, Knobloch, & Kelly, 2012). When implemented properly, this approach allows well-informed citizens to actively engage in the political process, ensures scientific evidence is considered, and increases the likelihood of meaningful policy outcomes.

5 Discussion and conclusions

Modern societies are complex, requiring scientific input in policy processes at all levels: global, national, and local. This is especially true when addressing some of the most pressing global challenges such as climate changes and a transition to a more sustainable future. Ensuring strong scientific advice and evidence-based policies is not enough. The public may still not accept these solutions or adapt their behaviour. A coordinated response between politicians, scientists and public is needed with strong collaborative and deliberative note.

The question of ensuring more sustainable way of living especially concerns local communities and municipalities as they are the ones governing practical ways of life and in the forefront when dealing with the consequences of global warming and related disasters. Complex relationships between science, politics and public can be even more challenging on the local level. On the one hand, local political institutions, especially in smaller places, form less expert groups and advisory boards. Their policymaking process happens within the broader scope of national policies and mostly deals with more practical governance. However, this chapter shows that local communities have strong

potential for collaboration between science, politics, and the public. Focusing on sustainable development may even act as a catalyst for such collaborations.

Case studies show that focusing on sustainable development, combined with supportive funding schemes, led to strong cooperation between local municipalities and university- or research-led projects. These projects created a new area for science-politics cooperation on local level. However, the question of actual policy implication of such projects remains. Furthermore, they rarely include the aspect of public, their attitudes and behaviour.

Citizen science and participatory research designs can offer a good starting point for bridging this gap. They also hold great potential for directly addressing sustainable development goals by providing access to additional data that scientists alone cannot gather. Even though some of the early definitions assumed policy implications and a strong tie of these projects to the actual societal problems as central to citizen science projects (Lewenstein, 2004), recent authors and institutions employ a more general definition of any scientific activity involving non-scientists. While citizen science contributes to public engagement, it rarely integrates politics and decision-making; this is where deliberative democracy can play a role.

This chapter discusses the potential of deliberative democracy as the concept that can act as a field for cooperation of all three spheres – science, politics and public, especially on local level. Deliberative process is often seen as a central process in democracies and deliberative democracy is often seen as a more complex type of direct democracy. It is a process in which citizens not only express their attitudes and opinions, but through complex argumentative discussions cooperate in governance. This assumes that citizens who cooperate possess some kind of knowledge – a skill to participate in deliberative process on one hand, and factual information to make reasoned judgements. In this sense, deliberative practices must include some type of scientific or expert input to ensure that participants are informed, and the deliberation process is of the appropriate quality. Furthermore, the issues at hand are often complex and technical and require involvement of highly specialized knowledge.

Deliberative democracy is often criticized as too logistically complex to implement in practice. However, there are many successful examples of mini-publics and citizens' assemblies that show its feasibility, especially on local level. This shows potential for local communities to address the challenges of sustainable development through ensuring tight cooperation between science, politics and public. However, the actual implication of such deliberative practices greatly depends on how these are organized. Here, more applied research is needed to determine the best possible model that would enable the most fruitful collaboration and actual practical outcomes.

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The Role of Media Education in Industry 5.0

MATEJA REK [1]

Abstract The article examined how the existing digital media education framework for children and youth in Slovenia aligns with the human-centric principles of Industry 5.0, focusing on human-machine collaboration, ethical engagement with technologies and the future workforce's digital competences. The article provides insights into how youth themselves perceive how they were media educated growing up in our society. Through analysis of focus group discussions, the study highlights potential gaps or deficiencies in how media education is currently conducted in our society, especially in the context of preparing children and youth for the challenges and opportunities of Industry 5.0.

Keywords: • Industry 5.0 • media education • media literacy • critical thinking • digital competences

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https://doi.org/10.4335/2026.2.4 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

Industry 5. 0 represents a paradigm shift in the evolution of industrial and technological practices as it introduces more human-centric approach, as opposed to the conceptualisation of Industry 4.0., which was more focused on the role of smart technologies themselves. Industry 4.0 revolved around the advancement of technologies like the Internet of Thins, artificial intelligence and automation, focusing on increasing data connectivity and enhancing productivity. Industry 4.0 is characterised by smart integration of machines, processes and workers with an aim to create smarter and more efficient manufacturing environment. The overarching goal is to improve productivity, reduce costs, drive innovation and offer new business models in manufacturing and industry. Industry 5.0 aims to introduce a more human-centric approach. Besides technological advancements it also pays attention to human creativity, decision-making and emotional intelligence in the development and use of smart technologies. In this context technologies are not seen merely as a replacement for human labour, which is quite a common assumption that many people have. This view does not fully capture the complex relationship between technology, humans and work, that has been rapidly changing due to numerous technological advancements worldwide. Some jobs are being displaced by robots, artificial intelligence or automatization, but new opportunities and changes in work are arising. The key will be ensuring that workers are prepared for these changes through education, reskilling and a focus on human-centred technology design (Barata & Kayser, 2023; Coelho et al., 2023; Oeij et al., 2024; Leng et al., 2022; Grabowska et al., 2022; Huang et al., 2022).

When examining the characteristics of Industry 4.0 and Industry 5.0, one can observe a clear parallel with the historical transition from classical management theories like Taylorism or Fordism to a more human-cantered paradigms like Human relations movement (Bruce and Nyland, 2011). While Industry 4.0 emphasized automation, efficiency and data drive processes, echoing classical management theories, Industry 5.0 introduces a more human-centric approach. It recognizes the value of human creativity, interactivity and well-being alongside technological advancement, aligning closely with human relations and socio-technical theories that emerged as critique of purely mechanistic vires of organizations. These parallel highlights how technological progress is once again prompting a re-evaluation of the human role in complex systems. Industry 5.0 seeks to harmonize human and machine capabilities, fostering environments where technology is not seen as a replacement for human labour but as a collaborative partner that can work together with human potential, building also on systemic features like emergent properties of complex systems. The power of smart machines should be leveraged to carry out complex, repetitive tasks and humans could make more space for creative and intellectually stimulating work. Human well-being, ethical considerations of digitalisation and sustainability of practices are central to industrial and technological advancements in Industry 5.0 as innovation, that is not solely driven by efficiency and productivity, but also by considerations to social impact. This shift calls for a re-

evaluation of workforce training and education systems, as people need new skills to thrive in this emerging digital ecosystem. In this context, human-centred education, such as media education can play a role in preparing individuals for the challenges and opportunities presented by this new industrial era.

In this article we explore the role of media education in shaping the future potential of children and youth in the context of Industry 5.0, particularly within Slovene society. We believe that education of children is highly relevant for skill full and well-educated workforce in a society as it lays foundation for the skills and knowledge but also values that individuals need in the workplace. The study uses focus groups as the primary data collection tool, to gather insights from youth on the current state of media education of children and youth. The article examines how the existing media education framework for children and youth in Slovenia aligns with the human-centric principles of Industry 5.0, focusing on human-machine collaboration, ethical engagement with technologies and the future workforce's digital competences. Through analysis of focus group discussions, the study highlights potential gaps or deficiencies in how media education is currently conducted in our society, especially in the context of preparing children and youth for the challenges and opportunities of Industry 5.0. The article provides insights into how youth themselves perceive how they were media educated growing up in our society. Understanding their views provides valuable perspective on whether current educational practices resonate with the needs and expectations of the younger generation.

2 Media education and its relevance for Industry 5.0

Media education can be described as a process of teaching and learning about digital media, content, technologies and the ways digital media shape society and individuals' understanding of reality. It equips people to be media literate, providing them with skills to access, analyse, create digital content and share it using various forms of media (Hobbs, 2010; Martensen and Hobbs, 2015; Livingstone, 2004). Media education traditionally included print, film and television, but today is heavily focused on digital platforms, social media and algorithm-driven content. It teaches skills of digital content analysis and evaluation and promotes critical thinking about how media messages are constructed and the intentions behind them. It helps individuals to recognize bias, misinformation, propaganda as well as reflections of the media content they are exposed to on their beliefs and behaviour. With the spread of online media, media users do not have to be only passive recipients of media content but active creators of media messages themselves. Media education encourages responsible content creation and ethical participation online and as such is essential for developing active, informed citizens in a media-saturated world.

Beyond consumption, it emphasises creative production of digital media content enabling learners to become content creators, not just passive audiences (Rek, 2023; Buckingham and Sefton-Green, 2018). Digital media education can, if implemented meaningfully,

create more media literate people, if it manages to combine obtaining technical skills of properly using digital media devices and software and creating healthy and smart media use habits, but also develop critical analysis of media content (received and generated) as well as ethical responsible media use. Such media literacy skills can support individuals to more effectively engage with the evolving landscape of human-machine collaboration that Industry 5.0 places a strong emphasis on. In that context, developing media literacy skills can be very useful for digital workers to navigate and critically engage with emerging technologies rather than passively relying on automated systems. The human-machine collaboration assumed by the Industry 5.0 can only work if humans are active creators and recipients of digital content. Workers in Industry 5.0 should possess the skills to interpret digital information, interact with AI-driven systems and make informed decisions based on data analytics. The ability to think critically and assess digital content is particularly important as AI-generated outputs or algorithmic recommendations are not free from bias or inaccuracies. Media education teaches and encourages individuals to question and refine these automated processes creating circumstance in which it is more likely that technology can serve human creativity and ethical considerations rather than operating independently of them. Understanding the ethical implications of digital technologies is becoming increasingly relevant. Workers should be able to recognize the potential consequences of AI-driven decision-making, from data privacy concerns to the unintended biases embedded within machine learning models. In the world of Industry 5.0 being media literate also means understanding how digital platforms collect and use personal data to tailor content for each user on a massive scale. Recognizing this process and how it affects what we see, believe or buy, is a key part of modern media literacy. As industries move away from mass production toward customized, consumer-driven manufacturing, employees will need to develop the ability to create and manage digital content, whether through AI interfaces, augmented reality experiences or interactive platforms. This shift demands a workforce that is not only technologically proficient but also capable of engaging with digital tools in a way that prioritizes human needs and preferences. As Industry 5.0 continues to evolve, those who are media literate can be better equipped to harness technology in ways to enhance their adaptability and continuous learning.

The media education of children and the media literacy of the broader population are deeply interconnected (Buckingham & Sefton-Green, 2018; Rek & Murko, 2024), as the fundamental skills developed in childhood shape the collective media competence of society. When children are thought media literacy skills from an early age, they have better chances to grow into adults who can critically engage with information and navigate digital environments more responsibly. These skills become even more crucial as individuals mature and encounter increasingly complex digital landscapes filled with persuasive advertising, algorithm-driven content and politically charged narratives. Furthermore, the media literacy of adults, particularly parents, teachers and policymakers, directly influences the quality of media education that children receive. If adults possess strong media literacy skills, they are better equipped to guide children in their digital

experiences. If adults lack these competences, they can struggle to provide children with the necessary tools to navigate the digital world effectively (Golob et al., 2023; Rek & Kovačič, 2018). So, we see, that the relationship between media education of children and youth and media literacy of the population is in a way cyclical and reinforcing. In a society where adults, either in their role of parents, teacher or policymakers, are aware of positive effects good quality media education can have on children's well-being, it is more likely, that a well-informed, critically engaged population is cultivated, which in turns can strengthen media literacy efforts for further generations. By recognizing these connections, a necessity of integrating comprehensive media education into school curricula, public policies and lifelong learning initiatives in highlighted, to ensure that both individuals and society can navigate the evolving digital landscape responsibly.

The integration of media education into early learning can also be seen as an investment in the future workforce of Industry 5.0 as Industry 5.0 thrives not just on automation, but on human intelligence guided technology and media literacy skills do support this human-centric approach.

3 Exploring Media Education Through Youth Narratives: Focus Groups Results

The purpose of the focus groups we conducted in 2023 was to explore young people's experiences of media presence, habits and upbringing while growing up in Slovene society. The analysis focuses on how young people describe their experiences with media education when growing up. Special attention is paid to the influence of various stakeholders (for example parents, school, peers, media industry) on media education, factors that in their opinion influenced the formation of media habits in childhood and suggestions from youth on how media education in our society could be improved in the future. The focus groups were conducted as part of the data collection activities of the Infrastructure Program on Media Literacy, funded by the Slovenian Research and Innovation Agency. The full report entitled "Youth Reporting on Media Education in Our Society" (Rek, Ljubotina and Bašin, 2023), along with the transcript and the developed paradigmatic model, is available on the programs' website. Two focus group discussions were conducted, one with six participants and the other with eight, all of whom participated voluntarily. They were all young people, purposefully selected first-year students of the study field Media and Journalism. The participants were previously informed about the topic, and the conversation was led and guided by a moderator according to the principles of a semi-structured interview. On the one hand, by selecting participants in this way, we aimed for uniformity, which should be reflected in their linguistic expression skills, media awareness and media literacy competencies, which would potentially provide better conditions for the development of critical reflections on the problem under consideration. With the same purpose, we pragmatically determined the approximate age (participants were 19 to 20 years old) of the interviewees, as we speculatively assumed that the memories of the younger generations of the selected period

of growing up are more accurate and as such promise more high-quality answers from the discussants. With our work, we wanted to gain a more in-depth understanding of media education and its related stakeholders, factors and relationships between them from the perspective of young people. Our sample is therefore improbable and purposeful and represents both a homogeneous and heterogeneous whole. We recognize the diversity of the group on several levels. Namely, the respondents come from specific micro and macro environments, from different Slovenian regions, socio-economic backgrounds and families; therefore, their experiences are unique, as they have been exposed to different upbringings within their home, formal education institutions and society due to the listed characteristics. In this way, by illuminating several aspects of the same area, we have gained a broader and more holistic view of the situation (Lamut and Macur, 2012). However, the findings that appear on a purposeful sample are not generalizable to the wider population, but are limited to the studied sample (Vogrinc, 2008), which requires special attention when interpreting the results.

Focus group discussions provided valuable insights into young people's experiences with media and digital devices throughout their upbringing. Participants' accounts revealed both common patterns and individual differences in media exposure, use and parental control. Most participants received their first mobile phones with a physical keyboard in primary school, primarily for communicating with their parents. They later switched to touchscreen smartphones, typically in their later years of primary or early secondary school. Access to personal devices was often influenced by family financial circumstances and in some cases older siblings or parents would donate used phones. Many participants reported that mobile phone use was prohibited in primary schools, but some still found ways to use them discreetly during breaks. Regarding the presence of media in households, television was usually in shared spaces, such as the living room, where families watched programs together. Some participants had personal televisions in their bedrooms, which they often used to watch series, play video games or follow sports. Video game consoles such as PlayStation, Nintendo and PSP were popular among several participants, particularly for recreational purposes. Many families also shared a single desktop computer, which was used primarily for schoolwork, internet browsing or gaming. Some participants highlighted limited access to personal computers until high school, when academic demands increased, prompting families to invest in additional devices.

Media consumption varied among individuals. While some preferred watching television shows and movies, others enjoyed playing video games or scrolling through social media. A few participants mentioned their early exposure to media through parental influence, such as listening to the radio while doing household chores or watching news reports. Others recalled their initial fascination with online platforms, including YouTube, where they enjoyed a variety of content. Social media use evolved over time, as platforms such as Facebook and Snapchat became popular while growing up and enabled communication with peers. Some participants even maintained dual social media profiles, one public and

one private, to selectively manage their digital presence. Owning a smartphone is recognized as a social necessity rather than a luxury, with some recalling classmates who were teased for not having a device. However, the importance of the latest model seems to have diminished over time, as even inexpensive smartphones offer similar features. This reflects a shift from device competition to a more general acceptance of widespread digital connectivity.

When discussing, how respondents experienced media education when growing up several key themes emerged, including parental restrictions and generational differences in media use and literacy. Parental controls and restrictions on media use varied across households. While some parents enforced strict rules, such as limiting screen time or prohibiting television viewing after a certain hour, others were more lenient. Several participants admitted to secretly using devices outside of permitted hours, such as playing mobile games or browsing social media late at night. Some participants linked their media habits to academic achievement, noting that parents were more permissive if their children were doing well in school. They recounted a variety of experiences with parental controls, from using secret passwords to bypassing screen time limits to confiscating devices as a form of discipline. Some mentioned that these restrictions parents set regarding digital media use were not always effective, as they found ways to reconnect to Wi-Fi or access devices through siblings or shared family technology. However, some also appreciated structured guidelines and parents' setting limitations to the digital media use, such as using monitoring apps, as they thought this helped them to develop more responsible media habits. Concerns were being raised about the impact of unlimited media exposure on children's behaviour. Some participants argued that too much screen time can lead to addiction and hinders the ability to cope with boredom or real-life challenges. Others pointed out that inappropriate digital media management can lead to increased aggression and difficulties in social interaction. Stories of younger relatives addicted to devices reinforced fears about the long-term consequences of early media exposure.

Across all narratives, participants expressed concerns about the early introduction of screens in toddlerhood, often initiated by parents seeking convenience. This practice was criticized as developmentally harmful. Several individuals emphasized the importance of human interaction, eye contact and shared activities, suggesting that digital overuse may disrupt foundational social-emotional development. Media use was described as deeply embedded in everyday life, from checking the time to shaping personal identity. Participants reflected on the blurring boundary between utility and addiction, where simple tasks (like using a phone alarm) easily spiralled into extended social media use.

A recurring theme was the stark difference between past and present access to technology. And with generational differences they did not mean only the difference in media use between adults as their parents and their teachers but also stressed that there is a difference in media use between their generation (in the year 2023 respondents were aged 19-20

years) and generation of children younger than they are. They think that even if only a couple of years have passed since they were children themselves, their media education and experience is significantly different from the children growing up now. Several participants noted that their own exposure to digital devices began later compared to younger generations, who now demonstrate an almost innate ability to use smartphones and tablets. The presence of media in early childhood is considered both impressive and worrying, with concerns raised about potential developmental consequences such as reduced attention spans and impaired social interactions.

Participants discussed the contradictory behaviour of their parents who, many times criticized their children's media use but were equally engrossed in their own devices. Some shared instances where parents have dismissed concerns about their own media habits, revealing a double standard. This highlights the broader challenge of digital parenting and the difficulty of setting consistent boundaries when adults struggle with digital media consumption.

The topic of privacy sparked the debate. While some acknowledged the necessity of parental oversight, others believe excessive monitoring, such as reading messages, confiscating phones or parental location tracking and surveillance, is a breach of personal boundaries. Participants shared cases where inappropriate media content led to parental concern but emphasized the importance of trust and open communication rather than using only invasive control measures. Several participants, voiced discomfort with parental intrusion into their digital lives when they were getting older. The phone was described as an extension of the self, where unrestricted access by parents felt like a violation of personal space.

Participants speculated about how future generations will navigate media advancements. One noted that today's youth will eventually find themselves struggling to keep up with new technologies, just as older generations do now. This recognition of inevitable technological shifts highlights the continuous cycle of adaptation and learning required to stay media-literate.

Across the discussions, parental influence is identified as the most dominant and enduring factor in early media socialization. Many participants recalled their first experiences with digital media through their parents, who often modelled media use behavioural, frequently without conscious intention. Parents, especially mothers, were described as regular users of social media like Facebook, contributing to a perceived double standard: while children's screen time was regulated, adult overuse went unchecked. This contradiction was interpreted by youth as hypocritical, sometimes leading to mistrust and efforts to circumvent parental controls. Parental regulation ranged from strict monitoring and punitive measures (for example phone confiscation after bad grades) to permissive and trust-based approaches, where children were allowed unsupervised access under the assumption of responsible use. However, in both scenarios, participants commonly noted

a lack of proactive or dialogic engagement about media risks and opportunities. Interestingly, children often responded to strict controls with covert or resistant behaviours, such as using mobile data to bypass home Wi-Fi restrictions or secretly using devices at night. These narratives highlight a disconnect between adult intentions and youth practices, as well as an underestimation of children's digital skills.

Participants emphasized that media usage and learning outcomes vary significantly across individuals, even within the same family. Several noted that media should not be simplistically blamed for poor academic performance as cognitive abilities and learning styles differ greatly among people. Some struggled academically despite limited media exposure, while others thrived despite frequent use. One participant noted that breaks between learning sessions, supported by brief media interaction, can enhance motivation, challenging the assumption that media is always a distraction.

Another recurring theme was the absence of communal media rituals in many households. In contrast, those who shared regular family activities, such as co-watching films or discussing online content, reflected more positively on their upbringing and demonstrated greater media awareness. These findings suggest that shared media experiences and open dialogue about digital media use in families may be more effective than only using restrictive controls in cultivating media literacy.

The role of schools in media education was another recurring theme. While primary schools largely implemented a ban on the use of mobile phones, in secondary schools, especially specialized institutions such as the Secondary Media and Graphic School in Ljubljana, they were more exposed to digital tools and technologies. Students coming from this school highlighted their opportunities to engage with various digital devices as part of their curriculum, which allowed them to develop digital media skills and literacy. Others noted that their educational institutions strongly emphasized safe digital media use but lacked a more holistic approach to media literacy programs.

Many participants of the focus groups expressed scepticism about the effectiveness of media education in schools. Some recalled attending workshops or courses but found them unmemorable and uninspiring. They argued that past generations did not require extensive media education due to less media exposure, whereas today, with the rapid development of digital platforms, there is a significant need for engaging and relevant educational content that can capture students' attention. The role of formal education in fostering media literacy was consistently described as inconsistent and, in most cases, insufficient. Although some participants cited school-based lessons, such as the “Safe.si” workshops or media-related vocational curricula, as informative, the majority described media education as boring, outdated or poorly implemented. Teachers were often viewed as technophobic. Participants highlighted that media education often began too late, typically after foundational habits and attitudes were already established through familial and peer interactions. In many accounts, the school’s failure to adapt to contemporary

digital realities contributed to student disengagement. Exceptions were noted in specialized institutions like high schools offering specialized media programmes, where media use was embedded in both theoretical and practical instruction. Some participants also perceived a generational digital divide between themselves and their teachers, which hindered meaningful discussions about online behaviour and risks. In several cases, students felt that they were more informed than the educators tasked with guiding them.

When talking about the role of peers in media related behaviour, participants reported that peers played a secondary role during early childhood, with family environments being more influential. When growing up however, peer influence gradually intensified, particularly around issues of connectivity and social inclusion, identity and digital conformity. Access to a mobile phone or social media account in adolescence was often driven by social expectations and fear of exclusion by peers, rather than intrinsic interest. Several narratives referenced bullying or marginalization of those who did not possess the "right" device or platform access. A form of digital social stratification emerged, wherein phone brands, apps used and as well as social media presence contributed to perceived status and belonging in school environments. Despite this, peers were not described as primary educators in media literacy; rather, their influence was described as indirect, affecting media habits through normative pressure and shared preferences (for example YouTube channels, TikTok trends). Participants did not report extensive peer-to-peer learning around digital skills or safety.

Interestingly youth respondents did not prominently mention media themselves as a stakeholder influencing their media habits or literacy. This suggests that young people may not fully recognize or critically engage with the media industry's influence on their media habits and literacy. It is possible that digital media are seen as implicit aspects of their environment, rather than forces they actively consider. Instead, youth associate media education with influences from families, educators and friends. Youth much more often mention digital media as a source of entertainment and rarely in their ability to educate or influence peoples' behaviour, mindsets or values. The lack of focus on the media industry as a stakeholder in shaping children's media habits and literacy when growing up highlights a potential gap in youth understanding of the broader forces shaping their media consumption. This finding suggests that media education could benefit from placing greater emphasis on explaining the influence of the media industry to children and youth, to help them recognize how digital media content is created and delivered to them and what the broader context of such digital media production is.

The analysis of focus group responses reveals that in addition to parental, school and peer influences, individual personality traits of both parents and children, as well as broader socio-cultural and technological contexts, play an important role in shaping media habits and media education during childhood and adolescence. One of the most prominent themes emerging from these narratives is the significant role of personal and familial characteristics. Participants emphasized that the character of the child and parent strongly

affects how media is used and integrated into daily life. For instance, some individuals reported that their generation, having grown up with limited digital exposure, had more opportunities to develop resilience and stronger self-regulation, which shielded them from excessive media influence. Others noted how parental inconsistency, such as a father watching sports during family meals, undermined efforts to model healthy media use. The degree of parental involvement and their own media habits had a direct impact on children's behaviour. In some families, encouragement of creativity, hobbies, sports and outdoor activities were used to successfully limit device use, while in others, a lack of control or technological awareness led to early signs of digital dependency, even among toddlers. These findings underscore that media education is not only a matter of external rules, but also of internal family culture and value systems. Strict parental controls were often bypassed by tech-savvy children, especially when communication and trust were lacking. Participants shared experiences of covert media use, creating secret accounts or feigning phone use in public spaces due to social anxiety. They highlighted the need for trust-based media related upbringing rather than approaches to media education that rely solely on restrictions and punishments. Some respondents noted that punitive parenting can suppress open dialogue, fostering secrecy and long-term emotional distance. Others recalled that punishment sometimes resulted in resentment or behavioural masking, rather than genuine understanding or internalization of rules.

Digital media was also identified as a tool for self-expression and identity formation. Adolescents and young adults reported using social platforms to explore and communicate their personal style, values and social connections. Some participants reflected on how music videos or online role models influenced their clothing choices and worldview. For others, digital platforms served as creative outlets or even sources of income, illustrating the dual role of media as both cultural influence and economic opportunity.

4 Discussion and Conclusions

The focus group discussions with youth on their media education experiences when growing up reveal a complex interplay of familial, educational and peer influences on media habits and media literacy development throughout childhood and adolescence. Respondents, aged 19 and 20 years, reflected on their formative experiences with digital devices, often highlighting the role of parents, schools and peers as key influencers. Moste of respondents acquired their first mobile phone in primary school, with family financial circumstances often shaping access. Parents played a dominant role in early media socialization, using a mix of restrictive and permissive strategies, although these approaches were often undermined by children's digital know-how and lack of open communication. Focus groups participants expressed concerns over early screen exposure among today's children, noting differences in that regard even between their generation and those only slightly younger. Schools were seen as inconsistent in their role of media educating children, with only specialized school programs in media production were

mentioned as offering meaningful engagement with digital media literacy. Peer had a growing influence in adolescence, especially around issues of entertainment, popularity, connectivity and belonging, but were rarely mentioned as source of education and guidance in obtaining digital or media literacy skills. The media industry itself was not prominently acknowledged by focus group participants as a stakeholder, which can suggest a limited awareness of broader systemic influences on their media consumption. Many narratives revealed tensions between control and autonomy, underscoring the importance of trust-based, dialogical approaches over purely punitive ones. Overall, the findings call for more comprehensive and proactive media education that includes critical thinking skills, analysis and evaluation of digital media content and skills of digital media content creation, as well as media education strategies, that recognize the interplay between personal agency, social context and structural forces.

The findings of this focus group study provide an interesting lens through which to consider the evolving role of media education in the context of Industry 5.0, a paradigm that emphasizes human-centricity in contract to more efficiency and technology-driven goals of Industry 4.0. As Industry 5. 0 brings renewed focus to the relationship between humans and intelligent technologies, the development of critical media literacy becomes not merely relevant but imperative. The observation that young people did not prominently mention the media industry as a stakeholder in their media upbringing or rarely mentioning of development of critical thinking skills as a part of their media education in schools or in their families, underscores a significant gap in critical awareness, one that is increasingly consequential in a hyperconnected, algorithm-driven media ecosystem.

In the conceptual framework of Industry 5.0, humans are perceived not just as users of digital technologies, but as creative collaborators with digital systems. This requires a form of digital media education that goes beyond just teaching and learning about functional digital skills like how to use the devices or software. It demands what the sociologist Margaret Archer calls meta-reflexivity (2007), a mode of self-reflection in which individuals critically evaluate both their own personal reality but also broader cultural and moral order in which those goals are formed. In the context of Industry 5.0, meta-reflexive media education could encourage learners to ask: Why am I co-creating with this algorithm? Whose values are being encoded into these data models? How does this collaboration reshape my sense of agency, responsibility and relationships with other? By encouraging such second-order questioning, educators could help children and youth to move from mere technical competences to ethical-critical stewardship of socio-technical futures, acting as responsible creators of digital content rather than passive consumers. This requires a form of media education that teaches critical thinking and ethical reflection of digital media content and use, as well as understanding of the socio-economic forces behind media production and data economies, that heavily determine both digital media content and its use. The focus group findings show that media education in schools remains largely inconsistent and insufficient in that regard often fails

to address these deeper dimensions. While participants described schools offering basic safety workshops or practical courses on media, few recalls having dealt with topics such as media ownership, consumerism, algorithmic bias, surveillance capitalism or the political economy of the media industry, all of which are relevant to Industry 5.0. Industry 5.0 also emphasizes interdisciplinary collaboration and human-machine symbiosis, which requires educational systems to prepare students not only to critically consume media but also to co-create in the digital environment in an ethically informed way. In this light, the findings argue for a reshaped model of media education that recognizes the role of industry as a powerful stakeholder and teaches young people to responsibly navigate and shape digital reality. Although it is not a traditional "factory-floor" actor, creative and media industries are among the strategic community of practice for Industry 5.0.

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Bridging Higher Education and Local Rural Development Through Student-Led, Work-Integrated Problem Solving

KLAVDIJA ZOREC [1]

Abstract This chapter explores the implementation and impact of two student-led, problem-based learning (PBL) projects, developed at the Faculty of Information Studies in Novo mesto, Slovenia, in collaboration with local industry and community partners. Situated in rural border regions, the projects engaged students in addressing real-world challenges through interdisciplinary teamwork, student-centered mentorship, and community co-design. Engaging in highly contextualized and reflective project activities, students developed practical solutions that responded directly to the needs of underserved local communities and organizations, such as digital tools for small businesses and a strategy for adult digital upskilling. The chapter highlights how structured, community-connected learning fosters student competencies, while supporting inclusive digitalization and rural sustainability, offering a transferable model for integrating socially responsive innovation into curricular and co-curricular structures in higher education.

Keywords: • problem-based learning • rural development • academic-community partnerships • digital inclusion • sustainable development

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https://doi.org/10.4335/2026.2.5 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

The growing digital and sustainability divides between urban centers and rural regions across Europe pose critical challenges for equitable development. Underserved rural border communities, in particular, often lack the infrastructural, educational, and institutional resources needed to fully participate in digital transitions and benefit from emerging opportunities. Higher education institutions, as knowledge hubs and agents of local and regional development, are increasingly called upon to address these disparities. However, their engagement with local communities—especially those in rural and border areas—often remains fragmented and insufficiently integrated into curricula and student learning experiences.

This chapter explores how guided, student-led projects embedded in higher education can enhance students' competencies while generating meaningful social and economic impact in rural areas. It presents two innovative case studies from the Faculty of Information Studies in Novo mesto, Slovenia: Digital Data Tool for Sustainable Business Optimization (Digi-POP) and Lifelong Learning for Digital and Green Rural Development (Vse-UP[1]). Both initiatives responded to locally identified needs and were implemented in partnership with local stakeholders, including businesses, adult education providers, and community organizations. Their novelty lies in combining structured, interdisciplinary Problem-Based Learning (PBL) with community engagement and cross-sectoral collaboration to address real-world challenges in under-resourced regions—thereby supporting both student development and community resilience.

The projects emphasized interdisciplinary teamwork, student-centered mentoring, and reflective practice as pedagogical strategies for advancing social innovation and sustainability goals. Specifically, the chapter (a) examines the design and implementation of these two student-led projects in rural Slovenia; (b) analyzes how academic–community partnerships and structured mentorship supported the learning process; and (c) assesses the perceived benefits and challenges for students, mentors, and local partners.

Through the lens of these two cases, the chapter contributes to the growing literature that positions higher education as an active player in regional innovation ecosystems. It argues that student-led, interdisciplinary project work can bridge the gap between theory and practice, while strengthening students' employability, social responsibility, and innovation capacities. In doing so, it demonstrates how relational, participatory, and place-based pedagogies can foster inclusive and sustainable transformation in rural border regions—offering insights for educators, policymakers, and institutions seeking to develop locally grounded and future-oriented models of education and community engagement.

2 Literature Review on PBL and Place-Based Innovation in Higher Education

Problem-based learning (PBL) has emerged as a pivotal instructional approach in higher education, particularly in light of global shifts driven by technological advancement, labor market transformation, and sustainability imperatives. In a world marked by socio-ecological disruption, deepening digital divides, and persistent equity gaps, traditional didactic, content-delivery models are increasingly viewed as insufficient for preparing students to engage with real-world complexity and contribute meaningfully to their communities (González-Pérez & Ramírez-Montoya, 2022). PBL centers students as active participants in collaborative, inquiry-driven learning that engages them with open-ended, authentic chalenges demanding interdisciplinary thinking, creativity, and civic responsibility (Dochy et al., 2003).

Rooted in constructivist learning theories (Vygotsky, 1978), PBL emphasizes experiential and contextualized learning through processes of social interaction, analysis and reflection. Students take ownership of their learning trajectories, developing higher-order competencies such as critical reasoning, metacognition, and data-informed decision-making (Boud & Feletti, 1997). Research consistently shows that challenge-based pedegogical approaches enhance student agency, motivation, and deep learning, while nurturing lifelong learning dispositions (Engeström et al., 1995; Gallagher & Savage, 2020). They also strengthen essential 21st-century competencies, including collaboration, communication, adaptability, and complex problem-solving (Bell, 2010; Zhou, 2018).

A defining feature of PBL is its focus on authentic learning—learning embedded in meaningful, real-world contexts that reflect the complexities and ambiguities of actual professional and societal challenges (Barrett & Moore, 2011). These contexts often demand integrative knowledge and engagement with diverse stakeholders. As such, teamwork and hands-on, work-integrated learning are central to effective PBL design. Real-world activities and project-based formats enable students to apply their disciplinary knowledge in new settings, refine professional behaviors, and engage in reflective practice. Group learning and project collaboration enhance peer-to-peer learning, intercultural competence, and social accountability, especially when aligned with community- or industry-based partnerships in work-based settings (Ferns et al., 2024).

Reciprocal relationship-building and academic collaboration between higher education and local communities significantly extend the educational impact of PBL by enabling co-designed, socioculturally embedded learning experiences. These partnerships support mutual knowledge exchange: students benefit from real-world exposure and mentoring, while community partners gain access to formal-science ideas and student-led innovation grounded in contemporary academic knowledge (Zorec, 2024). When learning experiences are situated within place-based, community-responsive frameworks, it can

become a vehicle for local and regional innovation and equity (Hernandez Gonzalez, 2023). Particularly in rural and border areas, community-university partnerships can facilitate tailored, cross-sectoral solutions and contribute to social cohesion, inclusion and sustainability (Mancini et al., 2022).

In this context, mentoring plays a pivotal role in guiding students through the complexity of interdisciplinary, community-engaged PBL projects. Faculty members are expected to scaffold the learning process by supporting decision-making, modeling inquiry, and cultivating students' disciplinary and transversal skills (Grabowski et al., 2008). Importantly, collaborative, project-based approaches require a shift in the student–teacher relationship. Students are no longer passive recipients of knowledge but become co-constructors and co-designers of learning processes (Amerstorfer & von Münster-Kistner, 2021). This shift aligns with the concept of academic communities of practice, where learning occurs through participation, dialogue, and shared meaning-making in collaborative social settings (Lave & Wenger, 1991). Within this community, students, academic teachers and external partners engage in joint inquiry and knowledge-building, blurring traditional boundaries between teaching and research, and this may foster a culture of trust, responsiveness and mutual growth.

The integration of students as partners in teaching and learning further strengthens the transformative potential of collaborative PBL. The "students as partners" approach emphasizes relational pedagogies, in which connection, care, and mutual respect are seen as central to student learning and meaningful engagement (Matthews et al., 2018). These pedagogies foreground the importance of dialogue, shared purpose, and genuine relationships in fostering student self-authorship and a sense of belonging (Baxter Magolda, 2004; Sanjakdar & Premier, 2023). As Gravett and Winstone (2020) argue, relational pedagogies extend beyond enhancing the enjoyment of learning; they involve reconfiguring power dynamics in education to promote inclusion, relevance, social justice, and care. From this perspective, place-based, collaborative PBL emerges not merely as an instructional method but as a relational and civic practice. By immersing students in authentic, context-sensitive challenges, it cultivates personal growth, social responsibility and transformative learning (e.g., Gruenewald, 2003; Wyness & Dalton, 2018).

These approaches align with the broader paradigm of future-oriented education, which emphasizes systems thinking, adaptability, and the ability to act in conditions of complexity and uncertainty. International frameworks, such as UNESCO's New Social Contract for Education (2023), call for learner-centered, values-driven education as a driver of sustainable and inclusive futures. Similarly, at the European policy level, several initiatives reinforce this direction. The European Pillar of Social Rights (European Commission, 2017) underscores the need for equal opportunities and inclusive, high-quality education, training and lifelong learning for all, while the Digital Education

Action Plan 2021–2027 (European Commission, 2020) prioritizes the development of digital competencies and infrastructure, especially in underserved regions. The Council Recommendations on a European Approach to Micro-credentials for Lifelong Learning and Employability (2022) promotes flexible, skills-based learning aligned with labor market needs. Furthermore, Smart Specialisation Strategies (S3) (European Commission, 2018) stress innovation through place-based approaches that reflect regional priorities and mobilize local strengths.

At the national level, Slovenia's Resolution on the National Programme of Higher Education 2030 (Ministry of Education, Science and Sport, 2022) affirms the role of higher education in fostering local and regional development, social inclusion, and digital transformation. The Digital Slovenia 2030 strategy (Government of the Republic of Slovenia, 2023) sets strategic goals for increasing digital literacy and inclusion, expanding access to digital resources, solutions and lifelong learning, and closing infrastructure gaps. The Implementation Plan for Slovenia's EU Cohesion Policy Programme 2021-2027 (Government of the Republic of Slovenia, 2021) further emphasizes inclusive, regionally differentiated development strategies that bridge sectors and support local innovation ecosystems.

In this context, collaborative, community-engaged PBL holds unique promise as a transformative mechanism for both student development and local-community advancement. When higher education institutions partner with rural and border communities through authentic, student-led inquiry, they become engines of civic engagement and community resilience. The two mentored, interdisciplinary PBL initiatives, Digi-POP and Vse-UP, exemplify this approach by supporting students' critical thinking, interpersonal competencies, and sense of agency, while simultaneously addressing real-world challenges in collaboration with local industry partners and community stakeholders.

3 Case Studies of Digi-POP and Vse-UP

Projects Digi-POP and Vse-UP involved interdisciplinary student teams working alongside academic mentors, industry, and local non-profit partners. Both initiatives were developed as a response to the pressing challenges faced by rural and border regions of Slovenia. These areas are often marked by demographic decline, youth outmigration, and limited access to digital infrastructure and education. These complex, systemic issues require innovative, context-sensitive approaches—ones that position higher education as a catalyst for regional resilience and inclusion. The focus was on building bridges between higher education, industry, and local communities in rural border regions to foster skills development, enhance employability, and drive sustainable practices in real-world settings. The two five-month mentored interventions were part of a co-curricular work-based program for students, funded by Slovenia's Ministry of Higher Education,

Science and Innovation. Both projects supported a broader institutional effort by the Faculty of Information Studies (FIS) to integrate authentic experiences, grounded in PBL, into higher education while promoting civic engagement and social responsibility among students.

The primary goals of the Digi-POP and Vse-UP projects included:

- to involve students in authentic, project-based learning experiences that address contemporary industrial and societal challenges
- to enhance students' knowledge and skills, making them more competitive and adaptable in the job market
- to promote digital tools and sustainable practices for economic and social inclusion, particularly in rural and border regions
- to contribute to updating educational content and methods to reflect labor market needs.

Both interventions were intentionally designed to foster a range of interdisciplinary competencies aligned with institutional learning goals and the evolving demands of the labor market and local communities. Project Digi-POP aimed to develop a digital data management tool for one rural company in the Slovenia's border area of Kočevje to optimize the organization's data processes, enhance energy efficiency, and support the transition to a low-carbon circular economy. The project was designed as an experiential learning opportunity that immersed students in authentic, real-world challenges. Students were actively involved in analyzing complex, real-time problems faced by the partnering company, exploring and proposing technical solutions, and refining their ideas through continuous collaboration with industry professionals.

Whereas project Vse-UP focused on supporting lifelong learning for working adults in a rural region of Ormož, Slovenia, by promoting skill development in digital and green practices. The goal was to analyze the barriers to participation in educational programs and co-create strategies and concrete actions that would encourage more adults to participate in sustainable and digital skills development. The project involved expert-led lectures, flexible learning sessions, and hands-on activities to enhance digital literacy and equip participants with the skills necessary for the modern job market and full participation in society.

3.1 Pedagogical Approaches and Student Engagement

Student engagement was grounded in Vygotsky's Sociocultural Theory of Learning and the framework of shared transformative agency within Cultural-Historical Activity Theory (CHAT). Vygotsky (1978) highlights the importance of socially mediated learning occurring within the learner's Zone of Proximal Development (ZPD), where meaningful interaction and scaffolding support knowledge construction. In these projects,

students collaborated closely not only with academic mentors and peers but also with local community stakeholders and industry partners, embedding their learning in authentic social contexts. The shared transformative agency perspective (Haapasaari et al., 2014; Sannino et al., 2016) further frames students as active agents capable of collectively addressing and reshaping the challenges of their local environments—rural digital exclusion in Vse-UP and sustainable business practices in Digi-POP. These frameworks helped to acknowledge and support the vital role of students in co-creating solutions that resonate with the lived realities and needs of their communities. The interventions used a variety of learning approaches and activities that placed student engagement and collaboration at the heart of project success, i.e., effectively addressing complex, real-world challenges in border rural areas, while also developing key competencies in communication, critical thinking, digital literacy, and civic agency (e.g., Van Nguyen et al., 2024).

- **Structured Project Work**

In both Digi-POP and Vse-UP, students engaged in highly structured and goal-oriented project activities that provided a clear framework for their work, directly aligned with pressing local challenges and needs.

Each project engaged students in a four-phase process: identifying challenges and opportunities through fieldwork and stakeholder interviews; co-designing solutions through iterative teamwork; developing and testing implementation proposals and tools; evaluating impact; and sharing new experiences and findings in public-facing events. The projects integrated principles of user-centered design, participatory research, and systems thinking, encouraging students to reflect critically on their roles and responsibilities in complex social ecosystems. Each student group also received clearly defined objectives, expected learning outcomes, guidance materials, and timelines. This structure supported students in managing their learning process through ongoing planning, progress monitoring, and evaluation, while maintaining flexibility to adapt to evolving community feedback. The structured approach supported students' development of project management skills tailored to real-world conditions, fostering a sense of responsibility toward tangible community impact.

- **Guided Inquiry and Mentorship**

The guided inquiry model placed students in the center of learning processes that were embedded in the local contexts. Mentors played a critical role in supporting students as they navigated unfamiliar community settings, rural digital divides, and small business realities. This mentorship involved not only academic guidance but also contextual insight into local socio-economic, cultural, or organizational dynamics. By providing scaffolding aligned with these realities, mentors helped students critically analyze and

adapt solutions to fit the unique characteristics and dynamics of the community and partners. This ongoing dialogue encouraged students' development of self-directed learning and transformative agency, empowering them to act thoughtfully and responsively within their local contexts.

- **Interdisciplinary Collaboration and Peer-Learning**

The projects' interdisciplinary teams mirrored the complexity of the local problems, which required insights from technology, social sciences, and business disciplines. This diversity enabled students to appreciate multiple perspectives rooted in community experience and local knowledge systems. Students collaborated closely with mentors and peers from different fields, fostering a culture of co-creation where local knowledge and practices were as valued as academic expertise. Peer mentoring and reciprocal learning were especially important in contexts where students encountered unfamiliar local conditions, enabling them to share strategies and collectively interpret the needs of local communities and partners. This approach aligns with research highlighting integrative approaches and cognitive diversity as essential for addressing multifaceted local challenges (e.g., Corbacho et al., 2021).

- **Design Thinking and Iterative Development**

Project activities incorporated principles of design thinking, encouraging students to empathize with local stakeholders, clearly define the problem, generate creative ideas, prototype solutions, and test them in real-world, local contexts. This iterative, user-centered process was particularly relevant in both projects: in Digi-POP, students had to understand the technological and operational needs of a local company; in Vse-UP, they explored the needs of adult learners and lifelong learning providers in a rural region. Design thinking helped students engage with user-perspectives and craft meaningful, sustainable and community-relevant innovations.

- **Hybrid Learning Environments**

The learning experience combined in-person fieldwork in local settings with digital collaboration, mirroring the increasingly hybrid nature of professional work and community engagement. Students conducted on-site research in rural communities and small enterprises, directly interacting with local actors and environments. Complementing this, interactive digital platforms enabled remote coordination and data analysis, reflecting the technological tools increasingly vital in regional development. This hybrid model and learning activities allowed students to experience firsthand the realities of border rural contexts while developing competencies essential for modern professional collaboration and societal roles (e.g., Wiek et al., 2021).

- **Multimodal Participation and Knowledge Expression**

To communicate their findings and solutions effectively within diverse local stakeholder groups, students employed a variety of expressive modes—visual, auditory, tactile, and digital. This multimodal engagement acknowledged the diverse communication preferences and accessibility needs in rural and industry settings. By creating infographics, interactive presentations, audio materials and other artifacts, students practiced translating complex information into accessible formats, thereby enhancing community understanding and buy-in. Such multimodal literacy is crucial for bridging academic knowledge and community contexts, supporting inclusive and participatory solution-development (e.g., Minelli de Oliveira, 2024).

- **Reflective Practice and Self-Evaluation**

Regular reflection and feedback cycles played a critical role in helping students assess their contributions in relation to local realities and project goals. To support self-awareness and promote continuous learning, students completed monthly self-reflection reports aligned with each project phase. These followed a structured format: first, students described their key activities and experiences, linking tasks to real-world applications; second, they identified knowledge and skills gained, both discipline-specific and transversal; and third, they identified areas for further development and articulated how they intended to improve. This process encouraged students to track their learning, bridge theory and practice, and cultivate a mindset of lifelong learning (e.g., Harvey et al., 2025). The reflections also served as a valuable feedback mechanism for academic mentors, helping them tailor support and address students' emerging needs.

In addition, guided group discussions, written reports, and peer feedback enabled students to continuously refine their understanding of project goals, concepts, and the nuances of local contexts. These metacognitive activities enhanced students' capacity to learn from experience, fostered self-regulation, and built resilience—essential traits for navigating complex and evolving professional environments. Moreover, reflection emphasized the value of sustained community engagement and the reciprocal nature of learning between students and local stakeholders.

3.2 Partner Involvement Strategies

Partner involvement in the Digi-POP and Vse-UP projects was strategically embedded across all phases of the project lifecycle. Rather than occupying a peripheral or consultative role, industry and community partners were positioned as active collaborators in planning, implementation, mentoring, and reflection. This comprehensive engagement strategy ensured that project outcomes remained relevant to

local needs, supported real-world learning, and fostered stronger ties between higher education and local ecosystems.

- **Structured Participation Across Project Phases**

From the outset, local partners were invited to co-design project activities in collaboration with academic mentors and students. They participated in needs analyses, helped define the scope of the challenges to be addressed, and contributed to shaping the structure of the interdisciplinary student project teams. During the implementation phase, their role extended to joint problem exploration, testing of prototypes, and ongoing evaluation of progress. This ensured that projects were grounded in real-world contexts and responsive to community and labor market needs in rural and cross-border areas.

- **Collaborative Problem-Solving and Co-Creation**

A cornerstone of the involvement strategy was co-creation through interdisciplinary teamwork. Local partners worked directly with students and academic mentors to identify practical challenges and develop targeted solutions. Their insights were critical in helping teams frame problems realistically and explore innovative, feasible responses. This hands-on collaboration promoted exchange of knowledge and good practices and fostered mutual learning, as partners contributed sector- and community-specific expertise while gaining exposure to student-driven, research-informed approaches and solutions.

- **Mentorship and Professional Guidance**

Industry and community partners served as mentors throughout the project, offering continuous domain-specific guidance to student teams. Their engagement included technical consultations, participation in regular feedback sessions, and provision of relevant tools, data, and access to workspaces or local environments. By acting as both advisors and facilitators, partners supported students in navigating thematic and operational complexities. Importantly, this relationship was bidirectional: local partners also benefitted from students' up-to-date academic knowledge and ideas, particularly in areas related to digitalization, inclusion and sustainability, contributing to a process of reverse mentoring (e.g., Murphy, 2012).

- **Contribution to Evaluation and Reflection**

Partner participation extended to the solution-development, evaluation and reflection stages of the projects. They took part in milestone presentations, offered structured feedback on the progress and outcomes of student work, and engaged in reflective discussions about the relevance and applicability of the project outputs. At the conclusion of their involvement, local partners shared oral and written reflections, which informed

project evaluation and helped identify good practices and opportunities for future collaboration and sustainable local development in rural areas.

- **Input into Curriculum and Educational Content**

To strengthen the long-term impact of the academic-community collaboration, partners were also included in the review and (co-)development of academic content and study activities. Their feedback informed the adaptation of teaching and learning practices to better reflect current trends and demands in local industry and community work, particularly in the areas of digitalization, interdisciplinary teamwork and inclusive design. This process helped align academic curriculum with practical needs in underserved local areas and improved the employability of future graduates.

- **Engagement in Dissemination and Public Dialogue**

Local partners played a key role in the dissemination of project outcomes. They were invited to co-present project findings, thereby sharing their insights and reinforcing the co-creative ethos of the project activities. Their involvement culminated in interactive hybrid seminars that brought together a wide range of stakeholders—students, educators, employers, NGOs, and local community representatives—to discuss the results and implications of the project. Through these opportunities, the partners contributed to broader public dialogue on how collaborative, community-engaged higher education can support local development and social innovation, particularly in underserved, border rural settings.

3.3 Project Outcomes and Gains

Student reflections, self-evaluations, and ongoing discussions with academic mentors and local partners from industry and non-profit sectors revealed the wide-ranging impacts of the Digi-POP and Vse-UP projects. These collaborative, real-world PBL experiences contributed not only to student learning and development, but also to meaningful outcomes for participating organizations and border rural communities.

- **Contextualized Learning**

The projects enabled students to engage with real challenges rooted in specific local, place-based contexts. Whether addressing the digital needs of a local business, or exploring how to reach underrepresented adult learners, students applied their academic knowledge to situations that demanded responsiveness, creativity, and socio-cultural awareness. This contextualized approach to learning enhanced the authenticity and perceived value of their educational experience.

Students consistently reported strengthened employability skills, particularly in problem-solving, communication, and project planning. They became more adept at identifying local stakeholder needs, setting realistic goals, and navigating real-life constraints—all within the framework of socially relevant, community-based projects. These experiences also helped students to see the direct link between their learning and the broader economic, digital, and social transformations underway in the local regions.

- **Collaborative Innovation Across Sectors**

The interdisciplinary and cross-institutional nature of the projects allowed students to co-create solutions in partnership with diverse stakeholders. Student teams worked across academic disciplines and collaborated closely with business leaders, non-profit staff, local community members and academic mentors. These interactions broadened students' understanding of how innovation emerges through dialogue, trust, and alignment of understanding and goals across different sectors and disciplines. The mentoring provided by both academic staff and local practitioners further strengthened their capacity to navigate complex problem-solving processes collaboratively. This cross-disciplinary approach mirrored the complexity of contemporary societal challenges, encouraging students to think holistically and communicate across fields.

- **Social Responsibility and Community Impact**

The projects helped students build a deeper understanding of the role education and technology can play in addressing inequality and fostering social cohesion. Through direct interaction with rural communities, particularly in areas facing socio-economic and digital exclusion, students gained awareness of the structural and interpersonal barriers that limit access, participation and productivity in industry, education and community life.

Working on projects with clear social aim, such as increasing adult participation in learning or improving digital capacity within local enterprises, allowed students to see themselves as contributors to social good. Many became more attuned to the value of listening, empathy, and trust-building in fostering inclusive practices and sustainable impact in local communities. At the same time, local partners benefited from new tools, plans, and pathways for engagement that were both accessible and aligned with local needs and values.

- **Future-Oriented Thinking**

Participation in these projects encouraged students to develop a forward-looking orientation. The process of co-designing solutions with long-term relevance required students to think beyond immediate deliverables and consider sustainability, adaptability,

and ethical implications. This cultivated a mindset oriented toward innovation, civic engagement, and active participation in shaping the future of their communities and professions.

Student reflections and team discussions indicated that students began to perceive themselves as emerging professionals with the agency and responsibility to influence broader systems. Many expressed increased interest in contributing to socially impactful work, particularly within their own regions, and recognized the importance of aligning personal ambitions with collective futures.

- **Tangible Benefits for Local Stakeholders**

Both projects resulted in practical, high-impact deliverables tailored to the needs of local partners and rural communities. In Digi-POP, students co-developed a user-friendly digital tool to support business data tracking and internal communication in a small local enterprise, contributing to the company's digital maturity and operational efficiency. In Vse-UP, students created a strategic framework featuring guiding principles and concrete action points to improve access and participation in lifelong learning for working adults in rural border areas. This document now serves as a valuable planning and advocacy tool for a local non-profit educational organization working with underserved adult learners.

These outputs demonstrated the practical value of student-led innovation and strengthened partnerships between higher education institutions and local stakeholders. Community and industry partners gained insights and solutions adapted to their specific contexts, while students deepened their learning through collaboration, community service, and impact. In this context, the projects supported broader goals of inclusion, sustainability, and local/regional development by promoting digital transformation, expanding educational opportunities, and fostering mutual learning between academia and the local, border rural environment.

4 Discussion

The implementation and outcomes of the Digi-POP and Vse-UP projects demonstrate the transformative potential of student-led, collaborative PBL when situated in authentic, community-facing contexts. By embedding student learning within real-life challenges in rural and border areas, these projects went beyond traditional notions of employability to foster civic-mindedness, innovation, and intersectoral collaboration, thereby responding to evolving educational and labor market trends and offering promising models for promoting inclusive digital and sustainable development in underserved localities.

The projects' outcomes affirm the widely acknowledged strengths of PBL in fostering critical thinking, collaborative inquiry, and motivation (Affandy et al., 2024; Dochy et

al., 2003; Ersoy & Baser, 2014). However, the project activities and student gains extend by operationalizing these benefits within the specific sociocultural contexts of rural Slovenia—areas that are frequently marginalized in digital transformation agendas and educational innovation. This context-sensitivity significantly enhances the authenticity and holistic dimensions of learning, as advocated by Kioupi and Voulvoulis (2022), and positions students as both learners and contributors to sustainable regional development. Unlike classroom-bound PBL, these projects required students to navigate unpredictable, ill-structured, and often politically or socially nuanced challenges in real communities, thereby sharpening not only their analytical skills but also their emotional intelligence, ethical awareness and sustainability competencies (e.g., Cörvers et al., 2016; Sterling, 2011).

Moreover, the integration of academic learning with community engagement and mentorship from local partners resonates with what Bovill (2025) and Molderez and Ceulemans (2018) describe as co-creation, where students, educators and external partners collaboratively co-generate new knowledge and solutions. This model not only enriches student outcomes, but also disrupts hierarchical models of knowledge production, recognizing the validity and value of local, experiential and context-specific knowledge. The resulting reciprocity enhances students' sense of agency and relevance, while also delivering tangible benefits to communities historically excluded from mainstream policy and innovation discourses.

From an institutional perspective, the Digi-POP and Vse-UP projects illustrate how higher education can evolve to meet the demands of future-oriented education. As UNESCO (2023) emphasizes, contemporary pedagogies must prepare students for complexity, uncertainty, and interdependence—qualities deeply embedded in these projects. The use of design thinking, hybrid environments and reflective practice not only equipped students with adaptive capacities, but also mirrored the real-world conditions of digital and green transitions, particularly in underserved regions. In doing so, the projects responded to the EU's twin transition agenda (digital and green) and contributed to broader social goals, such as territorial cohesion and inclusion.

Importantly, these initiatives challenge dominant narratives that position rural and border regions merely as recipients of development, instead highlighting their potential as active sites of innovation and learning. This reframing has significant implications for policy and practice. Too often, border and rural areas are overlooked in national strategies for digitalization or lifelong learning, despite their unique needs and contributions. By deliberately targeting these areas, the projects offer a replicable model for how student-led, university-supported initiatives can address systemic issues of demographic change, access and inclusion. The work aligns with calls for expanded understanding and integration of sustainability education that includes place-based learning and regional equity (e.g., Brundiers & Wiek (2017).

The outcomes of the projects also bring to light some key tensions and considerations for scaling such approaches. For example, while the structured scaffolding and mentors' guidance and support were essential to student learning and project success, they also demand significant institutional and social investment in terms of time, resources and coordination. Faculty workload, curriculum alignment and the establishment of sustained reciprocal partnerships with local stakeholders from underserved communities are all non-trivial challenges. However, the projects illustrate that when such investment is made, the return is substantial not only in student growth, but also in the relevance of higher education and its responsibility for and contribution to public good and sustainable future. Moreover, the effectiveness of interdisciplinary collaboration, while celebrated in both projects, depends heavily on creating a shared language, common understanding and mutual respect across disciplinary and professional boundaries and knowledge systems. This was achieved in part through deliberate facilitation and design-thinking processes, but it also required time and trust-building that may be difficult to engineer in more compressed or formal learning environments. These insights suggest the importance of longitudinal and flexible programmatic structures that can accommodate iterative development and reflection.

In terms of digitalization, the projects further demonstrate that access and inclusion must be fully considered at the heart of technological innovation. The development of a digital data management tool in Digi-POP was not only a technical endeavor but a socially embedded one; it addressed the needs of a small rural enterprise and was co-designed with its staff, ensuring usability and relevance. Similarly, Vse-UP's focus on adult digital literacy foregrounded equity, recognizing that digital skills are not merely economic assets, but enablers of full participation in contemporary society. This aligns with calls for digital competence approaches that are inclusive, contextual, and focused on empowerment (e.g., Redecker 2017). Sustainability was likewise understood holistically, extending beyond traditional, environmental considerations to include social and economic dimensions. Students were encouraged to think in systems, e.g., about energy efficiency, digital infrastructure, educational access, and labor market integration as interconnected challenges. This integrative approach echoes the need for cross-cutting skills such as systems thinking, autonomy, and collaborative problem-solving in uncertain contexts (e.g., Kolmos, 2020).

Given these notions and outcomes, the projects offer a compelling case for the value of border and rural regions as learning ecologies. Often framed as peripheral, these areas and communities offer unique and rich pedagogical opportunities to explore global challenges, such as climate resilience, digital equity, and demographic transitions, in highly situated ways. For students, this localization grounds abstract theories in lived experience and fosters a deeper connection to community, sustainability, and the potential of higher education as a driver of social innovation and community empowerment.

5 Conclusion

This chapter contributes to the growing body of literature advocating for higher education institutions to serve as active agents in local/regional transformation, particularly in underserved rural and border contexts. Drawing on two structured, student-led PBL projects implemented in Slovenia, the analysis illustrates how academic–community partnerships—when supported by meaningful student engagement, structured reflection, and interdisciplinary collaboration—can simultaneously enhance student learning and generate tangible benefits for local communities. The projects addressed place-specific challenges in education and business environments, demonstrating how work-based, intersectoral PBL can support inclusive digital and green transitions in geographically and socioeconomically marginalized areas.

The chapter underscores the potential of community-engaged, problem-oriented projects as a high-impact pedagogical approach that fosters holistic student development, aligns educational outcomes with labor market and societal sustainability needs, and facilitates participatory knowledge creation. It highlights the importance of engaging with local contexts, specifically the realities, constraints, and strengths of rural communities, as a means to deepen student learning and cultivate a sense of social responsibility. This work proposes an adaptable model for embedding relational, community-connected, and justice-oriented pedagogies into higher education, advancing both student development and the long-term resilience and empowerment of local communities.

Acknowledgment:

I would like to thank the students, community partners, and academic mentors who contributed to the projects presented in this chapter. Their active participation and willingness to share their experiences and insights were essential to the success of the initiatives. I also gratefully acknowledge the support of Slovenia's Ministry of Higher Education, Science and Innovation for co-funding the projects.

Notes:

[1] The chapter uses acronyms derived from the original Slovenian titles of both projects to maintain authenticity.

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Part III

From Local to European Policy Visions for Industry 5.0

Industry 5.0 in EU Macro-Regional Policies – Past, Present and Future

ALENKA PANDILOSKA JURAK [1]

Abstract The Industry 5.0 approach to the industry is to contribute to three of the Commission's priorities: "An economy that works for people", "European Green Deal", and "Europe fit for the digital age". One of the possibilities for implementing the approach is through Macro-regional Strategies and Interreg, an interregional cooperation programme, co-funded by the European Union. The beneficiaries of the programme are not only the EU member states that are part of the regions, but also regions from Albania, Bosnia and Herzegovina, Moldova, Montenegro, North Macedonia, Norway, Serbia, Switzerland, and Ukraine, which represents an essential spillover effect. This paper aims to present the integration of the Industry 5.0 strategy into macro-regional strategies and how it is already reflected in EU macro-regional strategies today. In doing so, we will also demonstrate opportunities for future macro-regional strategies to upgrade them or introduce elements of Industry 5.0 into macro-regional development.

Keywords: • Industry 5.0 • macro-regional strategies • interreg programmes • European Union

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https://doi.org/10.4335/2026.2.6 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

According to the European Commission documents, Industry 5.0 represents a significant evolution of industrial strategy in Europe. Unlike Industry 4.0, which is primarily technology-driven and focused on efficiency and productivity, Industry 5.0 is defined by the European Commission as an approach that goes beyond efficiency and productivity It is explicitly putting research and innovation at the service of the transition to a sustainable, human-centric, and resilient European industry. It places worker well-being at the centre of the production process and leverages new technologies to deliver prosperity that extends beyond jobs and growth, all while respecting the planet's boundaries. Industry 5.0 emphases industry's contribution to societal well-being, environmental protection, and economic prosperity. It also recognizes the role of industry in tackling societal goals such as climate action, social stability, and resource preservation, making it an enabler of the green and digital transitions. This human-centric, sustainable, and resilient model supports three major EU policy goals - an economy that works for people, the European Green Deal and Europe fit for the digital age (European Commission, 2024; European Commission, Breque, De Nul, & Petridis, 2021; 'Industry 5.0 - European Commission', 2024a).

The European Union envisions Industry 5.0 as a paradigm shift that transcends the technological focus of Industry 4.0, placing a greater emphasis on human-centricity, sustainability, and resilience (Vasquez et al., 2023). This evolution acknowledges the need to integrate human intelligence and creativity with advanced technologies, ensuring that industrial progress aligns with societal values and environmental responsibility (Kiran K., Adarsh, & Pattali, 2020). The EU's approach is driven by the understanding that technology should serve humanity, fostering inclusive growth and enhancing the well-being of citizens.

The purpose of this article is to demonstrate the integration of the Industry 5.0 concept into macro-regional strategies and related documents. The overview is not only important for assessing the traceability of the implementation of European policies and their retention but also for the eligible regions. The beneficiaries of the programme are not only the EU regions that are part of the Baltic Sea Region, the Alpine Region, the Danube Region and the Adriatic Ionian Region, but also regions from Albania, Bosnia and Herzegovina, Moldova, Montenegro, North Macedonia, Norway, Serbia, Switzerland, and Ukraine, which represents an essential a spillover effect to neighbouring countries facing similar regional challenges, which are strategic partners and potential future Member States

For the purpose of our researcs we determine the criteria according to which we will conduct the review, followed by the identification of these documents and their analysis. In defining the criteria, we rely entirely on the terminology and understanding of the

European Commission. We are aware that scientific literature, may deviate from the EU terminology, as it has its own insightsand understanding, but in this case, we must take into account the common denominator, which is the European Commission or its institutions.

This study adopts a qualitative document analysis approach to examine the integration of Industry 5.0 concepts into EU macro-regional strategies. First, we selected the documents and reviewed official EU strategy documents and action plans for the four macro-regions: Baltic Sea Region (EUSBSR), Adriatic and Ionian Region (EUSAIR), Danube Region (EUSDR), and Alpine Region (EUSALP).

The selection criteria included original strategy documents and their latest action plans (2009–2025) as well as documents published by the European Commission or official EU bodies. The analysis was guided by the European Commission's definition of Industry 5.0 ('Industry 5.0 - European Commission', 2024b), focusing on three pillars: Human-centricity, Sustainability, and Resilience. We searched for explicit mentions of "Industry 5.0" and related keywords (e.g., digitalisation, AI, circular economy, upskilling, social cohesion), including artificial intelligence (European Commission, 2021c), up-skilling and re-skilling European workers, particularly digital skills (European Commission, 2020b, 2025d), modern, resource-efficient, sustainable industries, transition to a circular economy (European Commission, 2025c), a globally competitive and world-leading industry, speeding up investment in research and innovation (European Commission, 2020b).

There are several limitations, the most important ones being the age of the documents and availability. Older strategies (2009–2015) predate the Industry 5.0 concept, so findings rely on thematic alignment rather than explicit terminology. The analysis is limited to publicly available EU documents and does not include national implementation reports.

2 Literature overview

The EU's Industry 5.0 priorities are multifaceted, encompassing technological advancements, ethical considerations, and societal impact. One of the central priorities is the human-centric approach, emphasizing the role of human workers in the advanced industrial landscape. It involves creating work environments that are safe, inclusive, and empowering, where human skills are valued and augmented by technology. The focus shifts from mere automation to fostering collaboration between humans and machines, thereby enhancing productivity and job satisfaction (Fant-Male & Pieters, 2025). The human-centricity necessitates a re-evaluation of workforce architecture and the development of new competencies for the future, moving beyond the traditional understanding of Industry 4.0's technological demands (Flores, Xu, & Lu, 2020). Furthermore, the European Commission advocates for increased research and industrial

attention on the human element, acknowledging the potential risk of an overemphasis on technology sidelining human resources (Ammirato, Felicetti, Linzalone, Corvello, & Kumar, 2023). This approach seeks to overcome limitations of traditional management by fostering greater agility and responsiveness to innovation and socio-cultural shifts (Alviani, Hilmiana, Widianto, & Muizu, 2024). It further underpinned by the necessity to address potential labour market disruptions, biases inherent in artificial intelligence, and emerging moral dilemmas arising from technological advancements (Khoruzhy, Khoruzhy, Kubrushko, Karataeva, & Bitkova, 2023). Moreover, the EU recognizes that sustainable development, encompassing environmental concerns, economic prosperity, and social well-being, is a cornerstone of Industry 5.0, differentiating it from prior industrial paradigms that primarily prioritized economic growth (Gao & Feng, 2023). This includes fostering a circular economy, reducing resource consumption, and promoting the use of renewable energy sources in industrial processes. The comprehensive vision for Industry 5.0 is deeply rooted in the EU's broader agenda for digital sovereignty and ethical technological development (Stix, 2021; Xia, 2024). Furthermore, commitment extends to ensuring resilience within industrial ecosystems, preparing them for future shocks and fostering adaptive capabilities in the face of global challenges (Costa, 2024; Kiran K. et al., 2020), whichs entails developing robust frameworks for evaluating the integration of human-machine collaboration, assessing the reduction in environmental footprint, and measuring the adaptive capacity of industrial systems (Sgarbossa, Grosse, Neumann, Battini, & Glock, 2020). Key performance indicators for human-centricity could include metrics related to worker well-being, skill development, and the effectiveness of human-robot collaboration, while sustainability indicators might encompass energy efficiency, waste reduction, and carbon footprint mitigation (Zeb et al., 2022). Moreover, resilience indicators could involve assessing supply chain robustness, cybersecurity preparedness, and the ability of manufacturing processes to adapt to unforeseen disruptions (Dahmani, 2024). These comprehensive indicators are crucial for tracking progress and ensuring that Industry 5.0 initiatives deliver tangible benefits across economic, social, and environmental dimensions. These metrics move beyond traditional economic output measures, reflecting a broader societal value proposition that integrates technological advancement with ethical considerations and sustainable practices. The emphasis on sustainability in Industry 5.0, particularly concerning environmental impacts, highlights a significant evolution from previous industrial revolutions, where the focus was predominantly on economic growth and technological advancement without sufficient consideration for ecological consequences (Cioffi, Travaglioni, Piscitelli, Petrillo, & Parmentola, 2020).

As mentioned above, the Industry 5.0 is framed around human-centricity, resilience, and sustainability, aiming to overcome some limitations of Industry 4.0 in achieving EU 2030 goals. (i) Human-centricity: Puts people—especially workers and communities—at the heart of the industrial process. Emphasizes well-being, safety, inclusion, continuous upskilling, and treating human capital as an investment (European Commission et al.,

2021; 'Industry 5.0 - European Commission', 2024a), (ii) Sustainability: Seeks to ensure that industrial activity actively contributes to environmental restoration and climate goals, using circular and regenerative production models and efficient resource use (European Commission, 2021b; European Commission et al., 2021; 'Industry 5.0 - European Commission', 2024a), and (iii) Resilience: Focuses on building robust, adaptable industry that can withstand economic and supply shocks, including pandemics and geopolitical disruptions (European Commission et al., 2021; 'Industry 5.0 - European Commission', 2024a). This shift opens up new avenues for macroregional policies that focus on sustainable and inclusive industrial transformation (Jiménez Rios, L. Petrou, Ramirez, Plevris, & Nogal, 2024). A complex hybrid evaluation model has been proposed to assess projects improving sustainability and health in regions and cities, explicitly integrating Industry 5.0 concepts alongside the European Green Deal. It suggests policy frameworks at regional levels are beginning to embed Industry 5.0 principles for sustainable development (Kelemen, Gavurova, & Polishchuk, 2022). Research on regional inequalities and technological dependence highlights the fractal and networked structure of EU regions, stressing the importance of tailored Smart Specialisation strategies that promote diversification towards advanced technologies—aligned with Industry 5.0's push for technological and social innovation in macro-regions (Wirkierman, Ciarli, & Savona, 2025).

The EU's industrial policy debates emphasize strategic autonomy and competitive sustainability but also reveal tensions between ecological goals and prevailing economic models. This critique underlines the need for post-growth industrial policies that integrate Industry 5.0 values, which is essential for shaping macroregional development strategies (Bärnthaler, Mang, & Hickel, n.d.; Cappellin, 2020). While studies on Industry 4.0 diffusion at regional scales exist, the specific integration of Industry 5.0 within EU macroregional policy frameworks has yet to be the primary focus, but is gaining attention as Industry 5.0 concepts proliferate in academia and policy discussions (De Propris & Bailey, 2021; Testi, 2023).

3 Research

3.1 Key Priorities of Industry 5.0 in the EU

The EU's perspective on Industry 5.0 involves integrating government, university, industry, and civil society with the environment to shape innovation and entrepreneurship ecosystems (Carayannis, Christodoulou, Christodoulou, Chatzichristofis, & Zinonos, 2022). This perspective is embedded in policies and initiatives aimed at fostering a competitive and sustainable industrial base (Camarinha-Matos, Rocha, & Graça, 2024). By emphasizing the importance of human capital and ethical considerations, the EU aims to create a future where technology empowers workers, promotes environmental

stewardship, and builds resilient supply chains (Dhirani, Mukhtiar, Chowdhry, & Newe, 2023).

3.2 Industry 5.0 in the macro-regional context

Since 2009, the EU has been developing strategies for the Baltic, Danube, Adriatic – Ionian Sea and Alpine macro-regions. These macro-regional strategies are instruments of EU governance that wishes to combine territorial cooperation and community cohesion policies with intergovernmental "regional cooperation" involving EU member states and partner countries. They aim to mobilise EU member states and non-member states to promote and coordinate territorial and cross-governmental cooperation by creating comprehensive governance structures for cross-sectoral and cross-border policy coordination in the areas of transport infrastructure and environmental protection. Both macro-regions and macro-regional strategies have aroused growing interest in multiple disciplines, including geography, regional planning, political science, and public administration, raising questions about their impact on existing territorial co-operation practises and their relevance for regional co-operation (Gänzle, Stead, Sielker, & Chilla, 2019; Gløersen, Balsiger, Cugusi, & Debarbieux, 2019). A characteristic of macro-regional cooperation is that the strategies cover different policy issues and are not limited to a single topic, such as environmental protection of shared marine or river systems. However, some topics play a more vital role in certain macro-regional strategies than others, reflecting regional geographical specificities and political priorities. These areas vary from strategy to strategy and reflect specific regional interests and priorities. The results in the four macro-regions are very different, which is partly due to their development periods , however, they vary depending on the geopolitical context, organisational landscape, administrative capabilities and political priorities (Gänzle et al., 2019). Promoting macro-regional integration facilitates the flow of knowledge, information, technologies, and good practises, which is particularly important for regions lagging behind in development (Pandiloska Jurak, 2024).

Macro-regional strategies can play a role in future cohesion policies. Indeed, they represent a meso-level intervention that can effectively implement transnational multi-level governance and co-operation, including in innovation policy (Faludi, 2010; Metzger & Schmitt, 2012; Pagliacci, Pavone, Russo, & Giorgi, 2020; Stead, Sielker, & Chilla, 2016). Promoting territorial cooperation and cohesion leads to better economic, social and territorial outcomes (Pagliacci et al., 2020).

The macro-regional strategies are in synergy with the Interreg transnational programmes, which fund projects and support governance. Macro-regional strategies and Interreg programmes strive to reduce disparities in the levels of development, growth and quality of life in and across Europe’s macro-regions .

3.3 European Union Strategy for the Baltic Sea Region

For the Baltic macro-region, we obtained three documents- the European Union Strategy for the Baltic Sea Region (European Commission, 2009), the European Union Strategy for the Baltic Sea Region, Action plan 2015 (European Commission, 2015), and the European Union Strategy for the Baltic Sea Region, Action plan 2021 (European Commission, 2021a). The European Union Strategy for the Baltic Sea Region (EUSBSR) identifies its four pillars -environment, prosperity, accessibility, and security. The strategy was adopted in 2009, so there is no point in looking for concepts related to Industry 5.0 in its thread, but we can certainly expect this in the action plans. These two describe the framework for regional cooperation. The plans present in detail the governance structures (such as national coordinators and thematic policy areas), the financing methods, and the objectives of the strategy ("Save the Sea", "Connect the Region", and "Increase Prosperity"). The documents emphasize the integration of horizontal aspects, in particular climate change and cooperation with neighbouring non-EU countries in 14 policy areas, such as transport, energy, health, innovation, and culture. In addition, they describe concrete actions and flagship projects within these policy areas, with the aim of promoting sustainable development, competitiveness, and security in the Baltic Sea region.

The Action Plan for the EU Strategy for the Baltic Sea Region (EUSBSR) and its 2021 update do not explicitly mention the term "Industry 5.0", however, the 2021 updated Action Plan addresses a number of related concepts relating to digitalisation, innovation, and industrial development:

- Innovation and digital transformation - the Innovation policy area focuses on digital innovation and transformation. Digitalisation, automation, 5G technology, blockchain technology, and synchromodal transport solutions are mentioned as key instruments to reduce bottlenecks and improve capacity utilisation.
- Industry 4.0 - the Innovation policy area explicitly mentions "Industry 4.0" as a key challenge for small and medium-sized enterprises (SMEs) and addresses it through international sharing of best practices. The project INNOCAPE: Industry 4: transforming innovation ecosystem through better capacity of public enablers is also planned.
- EU Industrial Strategy - the Action Plan links to the EU Industrial strategy as one of the key actions of the European Green Deal.
- Digital Single Market - the Innovation policy area contributes to the realisation of the Digital Single Market.

Thus, the revised action plan (2021) emphasizes advanced digital technologies and transformation ("Digital innovation and transformation" and "Industry 4.0"), although it does not use the specific phrase "Industry 5.0".

3.4 European Union Strategy for the Adriatic and Ionian Region

For the Baltic macro-region, we obtained two documents, namely the European Union Strategy for the Adriatic and Ionian Region (European Commission, 2014) and Action Plan of the EU Macro-Regional Strategy for the Adriatic and Ionian Region (European Commission, 2025a).The strategy, which includes four EU Member States and six candidate or non-member countries, focuses on promoting cooperation and sustainable development in the region and is aligned with objectives such as the EU Green Deal and the enlargement process. The core of the revised plan consists of five pillars – transforming the blue and sustainable economy, connecting the region (transport and energy), environmental quality, sustainable tourism, and improved social cohesion, with the fifth pillar (social cohesion) being a new addition. The sources also highlight the importance of horizontal themes, such as digitalisation and EU enlargement, and sustainable financing of the strategy's objectives, using existing EU financial instruments, in particular cohesion policy funds and the Instrument for Pre-Accession Assistance.

The term "Industry 5.0" does not appear explicitly in the documents, but they extensively address related concepts and objectives that are often linked to the topic of "Industry 5.0", such as:

- Green and digital transitions - the documents strongly emphasise the need to accelerate the green and digital transitions. This "twin transition" is seen as essential for the competitiveness of businesses, the sustainable development of tourism, and the modernisation of transport and energy systems.
- Social cohesion and training - the revision of the Action Plan introduced a new fifth pillar focused on improved social cohesion. This pillar aims to address skills, education, and inclusion of young people, enhance labour market opportunities, and tackle demographic, industrial, and geopolitical challenges, themes that closely overlap with Industry 5.0's focus on human-centredness and resilience.
- Innovation and research - the plan emphasises that all pillars must contribute to strengthening research and innovation, including innovative solutions in the areas of blue and green technologies, social innovation, and digitalisation.
- Although no explicit reference to "Industry 5.0" was madethe themes of training for future labour markets, accelerating innovation, and social transition are key parts of the revised strategy. Moreover, all the objectives addressed in the analysed strategies are key priorities and are largely covered by the revision of the EUSAIR Action Plan 2025. In particular, the revised Action Plan places strong emphasis on:Human-centricity in digital technologies (including artificial intelligence)_ the revised Action Plan highlights digitalisation as a cross-cutting theme, integrated into all pillars of the strategy. Although the term "human-centric approach" is not directly used, the emphasis is on social cohesion and inclusion.

- Up-skilling and re-skilling- the strategy strongly emphasises the acquisition and development of relevant skills for future labour markets, which is a key part of the new Pillar 5 – Improved social cohesion.
- Modern, resource-efficient and sustainable industry and the transition to a circular economy-Circular economy is identified as a cross-cutting topic, which is crucial for achieving climate neutrality and reducing pressure on natural resources.
- Globally competitive and leading industry, accelerating investment in research and innovation- Research, innovation and development is identified as a horizontal topic that must be addressed by all pillars in order for the region to prosper.

3.5 European Union Strategy for Danube Region

For the Danube macro-region, we obtained two documents - European Union Strategy for Danube Region (European Commission, 2010) and European Union Strategy for Danube Region Action Plan (European Commission, 2020a).The documents address the main challenges facing the region, such as organised crime, corruption, climate change and social inequality, while highlighting opportunities such as the rich natural and cultural heritage and development potential. The strategy is structured around four pillars and twelve priority areas – from transport connectivity and sustainable energy to environmental protection and institutional capacity building – with clear actions and targets to foster transnational cooperation. The EUSDR Action Plan is designed as a 'rolling' and integrated framework, requiring national commitment and coordination of funding from different EU and national instruments to achieve tangible results.

The 2010 Action Plan for the European Union Strategy for the Danube Region (EUSDR) and its 2020 revision (Commission Staff Working Document SWD(2020) 59 final) do not explicitly mention the term 'Industry 5.0'.

The 2020 revision of the Action Plan, although it does not mention "Industry 5.0", includes certain advanced concepts and objectives that are relevant for the digital transformation and technological competitiveness of the region, in particular under Priority Area 8 (Competency of Enterprises):

- Digitalisation and Artificial Intelligence (AI) - the 2020 update explicitly mentions new topics such as artificial intelligence. The Action Plan highlights that digitalisation brings challenges and new opportunities, with cooperation between the Danube countries being key to preventing growing disparities.
- Digital transformation of SMEs - the document states that the competitiveness of enterprises, especially small and medium-sized enterprises (SMEs), needs to be improved by generating concrete technological offers, technological requirements, and knowledge exchange. It highlights that SMEs are facing the effects of the digital transformation.

- Digital Ecosystem and AI (PA 8) - the objectives of the Action Plan include: Establishing an Innovative Digital Ecosystem in the Danube Region to support SMEs in tackling the challenges of a digitalised world (ACTION 2) and strengthening the use of Artificial Intelligence (AI) technologies in SMEs in the Danube Region (ACTION 5). The aim is to establish five new Digital Innovation Hubs (DIHs) in the Danube Region by the end of 2024, which would spread artificial intelligence, cybersecurity, and high-performance computing.
- Knowledge Society (PA 7) - the Action Plan envisages exploiting the benefits of digitalisation for citizens, businesses, and governments and developing skills for smart specialisation, industrial transition, and entrepreneurship. The Digital Europe Programme (DEP) is mentioned as supporting capacity building (including AI).

It is important to note that the 2020 revision of the Action Plan refers to digitalisation as the "third industrial revolution". Although this terminology is not aligned with the more recent concepts of Industry 4.0 or 5.0, the measures relating to artificial intelligence, the digital ecosystem, and the improvement of digital skills are in line with the general objectives of advanced industrial modernisation. The original 2010 Action Plan (COM(2010) 715 final) focuses on the Europe 2020 strategy and objectives, such as improving competitiveness and sustainable development, but does not mention specific industry terminology such as "Industry 5.0". The concepts of Industry 5.0 are also reflected in:

- Adopting a human-centric approach to digital technologies, including artificial intelligence (Proposal for a Regulation on Artificial Intelligence)- The 2020 Action Plan addresses artificial intelligence (AI) and digitalisation.
- Upskilling and reskilling Europe's workforce, in particular digital skills (Skills Agenda and Action Plan for Digital Education)- the revised Action Plan places a strong emphasis on improving skills and knowledge (Pillar 3: Building Prosperity).
- Modern, resource-efficient and sustainable industry and the transition to a circular economy (Green Deal); the concepts of Green Europe and sustainable development are central to the revised Action Plan (PO 2 – a greener Europe).
- A globally competitive and leading industry, accelerating investment in research and innovation- promoting competitiveness and innovation is a key pillar of the Action Plan (Pillar 3: Building Prosperity).

3.6 European Union Strategy for the Alpine Region

For the Alpine macro-region, we obtained two documents, namely the European Union Strategy for the Alpine Region (European Commission, 2011) and Revised Action Plan of the EU Macro-Regional Strategy for the Adriatic and Ionian Region (European Commission, 2025b). Both action documents constitute a framework for cooperation, detailing the priorities, objectives, and actions aimed at improving the economy, sustainable development, and institutional cooperation in each of the regions concerned.

The EUSALP documents focus on thematic areas, such as economic growth, mobility, and the environment in the Alpine region. In contrast, the EUSAIR resources define five pillars, including the blue economy, connectivity, and social cohesion, with an emphasis on the digital and green transitions. Both documents emphasise that the strategies do not have their own financing, but rely on the mobilisation and coordination of existing national and European funds.

The 2015 Action Plan (for the EUSALP strategy) and the 2025 Action Plan update (for the EUSAIR strategy) do not explicitly mention the term "Industry 5.0". The 2015 EUSALP Action Plan focuses on the challenges and objectives that were relevant at the time, including economic growth and innovation (policy theme 1), and supports the Europe 2020 strategy. The key concepts related to industrial and technological development contained in the documents are:

In the EUSALP Action Plan (2015):

- Innovation ecosystem - Objective 1 was to develop an efficient research and innovation ecosystem that would combine the existing potentials of the Alpine Region and exploit synergies in strategic sectors.
- Strategic sectors - the focus was on increasing the economic potential of strategic sectors such as agriculture, forestry, tourism, energy, and the high-tech sector.
- Digital connectivity - the importance of electronic connectivity for opening up the entire Alpine Region to the information economy and society is mentioned, especially in view of the declining rural regions, which was addressed under theme 2 (Mobility and connectivity).

In the revised EUSAIR Action Plan (2025):

- Green and Digital Transitions - the document strongly emphasises the need to accelerate the green and digital transitions as they are key to achieving the goals of a sustainable and competitive economy.
- Innovation and Research - this is listed as a horizontal and cross-cutting theme. The aim is to strengthen research and innovation in the region, align science and research in candidate countries with the European Research Area (ERA), and encourage innovative small and medium-sized enterprises (SMEs) to exploit the potential of green and digital solutions.
- Blue and Green Technologies - Pillar 1 (Blue Sustainable Economy) focuses on promoting research, innovation, and business opportunities in blue economy sectors, with a focus on blue and green technologies.
- Digitalisation and AI - Digitalisation is considered a cross-cutting theme. The establishment of a network of digital innovation hubs and the integration of digital innovation tools such as artificial intelligence (AI) and the Internet of Things are prioritised. AI is also mentioned as a key instrument in the management of energy networks.

Although the specific term "Industry 5.0" (which emphasises sustainability and people at the centre) is not used, the EUSAIR 2025 Action Plan covers related concepts such as the green transition, digitalisation, and social cohesion (Pillar 5, which emphasises labour market coordination, skills, and equal opportunities), which are essential components of modern industrial strategies:

- Adopting a human-centred approach to digital technologies, including artificial intelligence (Proposal for a Regulation on Artificial Intelligence),
- Upskilling and reskilling Europe's workforce, in particular in digital skills (Skills Agenda and Digital Education Action Plan),
- Modern, resource-efficient and sustainable industries and the transition to a circular economy (Green Deal),
- A globally competitive, world-leading industry, and boosting investment in research and innovation.

4 Discussion

To briefly summarize, the selected macro-regional strategy documents address many areas that are part of the understanding of the term Industry 5.0, even though the basic documents do not include more detailed elements due to their age. The analysis reveals that while the term Industry 5.0 is not explicitly present in EU macro-regional strategies, many of its core principles - human-centricity, sustainability, and resilience—are embedded in recent action plans. Concepts such as digitalisation, circular economy, social cohesion, and innovation ecosystems strongly align with Industry 5.0 objectives, indicating an implicit integration of its values.

However, an examination of these elements indicates that, whether intentionally or unintentionally, the fundamental term was entirely omitted. It is unsurprising that certain strategies do not incorporate this term, given that they were formulated as early as 2009, and some have not yet undergone revision. Nevertheless, one would anticipate that more recent action plans would introduce and clearly define this concept. The underlying issue may lie in the outdated nature of the strategic documents, suggesting that a comprehensive update should precede any enhancement through action plans. It is also plausible that the authors of these plans remain constrained by frameworks established over fourteen years ago.

This is not problematic in itself, especially if we focus only on the narrow field of document review. However, the challenge arises when looking at the macro perspective, i.e., the desire for a unified overview of the integration of the European strategy, its integration, implementation and reviews of indicators. The inconsistency leads to a lack of transparency, loss of common ground, and ultimately, loss of the terminology itself, its understanding, and its essence. Industry 5.0 is not a term that would otherwise be invented

by officials for the purposes of the new financial perspective. The term is, and will continue to be, used across all domains concerned with the development of industry and services, encompassing scientific fields such as industrial development, change management, human resource management, societal responses to new technologies, and education. However, it will not be possible to do clear and transparent studies of how the EC responded to this new level of industrialization. It will be even more difficult to review the use of funds in this area. This also completely loses transparency, not only for researching European policies as such, but also for determining their effectiveness and achieving key indicators. It is also very clear and evident that the systematic approach to building policies from the top down has been completely lost in the drafting of documents.

Given the above findings, we can consider possible solutions avoid the above mentioned issue and to strengthen the link between Industry 5.0 and macro-regional development. The guidelines offered for future strategies development could be grouped into the following three sets: (i) update existing frameworks to explicitly reference Industry 5.0 principles, (ii) introduce measurable indicators for human-centricity, sustainability, and resilience, enhance governance transparency by aligning macro-regional objectives with EU industrial policy goals (iii) promote capacity building through upskilling, digital innovation hubs, and cross-border research collaboration.

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How to Overcome the Legitimacy Crisis of European Democracy?

MATEVŽ TOMŠIČ [1]

Abstract Sustainable development of democracy in Europe cannot be taken for granted. We witness tendencies, both external and internal, that are detrimental to democratic political life. The main issue of the chapter thematises the possibilities for strengthening democratic legitimacy and enhancing problem-solving capacity in the EU. It analyses key deficiencies in the functioning of European democracy that need to be tackled. The first deficiency is a lack of leadership, where political decision-makers often lack the vision, wisdom, and courage to face the challenges of the current historical moment. This is coupled with insufficient problem-solving capacity, characterised by poor coordination and low efficiency (despite sufficient material and intellectual resources). This is related to the rise in political distrust of the citizenry toward political and other elites at both the national and EU levels, which is associated with the rise of Euroscepticism. One should also add a relatively weak awareness of a common European identity, not only among ordinary citizens but also among elites. The author claims that political and other elites bear the bulk of responsibility for the legitimacy crisis in Europe.

Keywords: • democracy • European Union • legitimacy • leadership

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https://doi.org/10.4335/2026.2.7 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

Sustainable development of democracy in Europe cannot be taken for granted. For a long time, we Europeans lived under the belief – or rather, the illusion – that the democratic order established after the Second World War was eternal. Likewise, peace and security on the 'old continent' were supposed to be infinite. In recent years, however, all of this has been seriously called into question. The key turning point was Russia's military aggression against Ukraine in February 2022. It has become clear that the autocratic regime of Vladimir Putin, obsessed with the desire to restore the Russian empire, represents a serious threat to the European democratic order. An additional problem is that Europe lacks the appropriate defence and security instruments to counter this and similar threats effectively, so it is heavily dependent on the United States of America in this regard.

Nowadays, there are tendencies, influenced by both external and internal factors, that are detrimental to democratic political life. Among external threats, the role of global and regional anti-democratic centres of power shall be stressed. Besides Russian aggressive expansionism, one can state Islamic terrorism as also increasing the power and international influence of authoritarian China. Among internal forces, we can count the rise of populism, anti-European sentiments, and political extremism. There is a widespread perception of the inefficiency of democratic institutions and of the detachment of political elites from the needs and interests of ordinary citizens, leading to declining political trust in several EU countries.

The main issue addressed in the chapter concerns ways to strengthen democratic legitimacy and enhance the European Union's problem-solving capacity. According to Lipset (1959, p. 29), legitimacy can be perceived as the "capacity to produce and maintain the belief that existing political institutions, or norms, are the most appropriate for society".[1] Legitimacy results in the consent of the citizenry with the fundamental norms and principles of a particular political setting as well as their conduct in accordance with them. The legitimacy of the democratic system thus presupposes a consensus regarding the citizen body's commitment to key democratic norms and principles, as well as the recognition of this type of institutional setting as the only acceptable political alternative (Tomšič, 2002). It is essential to emphasise that the term primarily refers to transnational governance, that is, political processes within the framework of the European Union's institutions. It analyses key deficiencies in the functioning of European democracy that need to be tackled. The first deficiency is a lack of leadership, where political decision-makers often lack the vision, wisdom, and courage to face the challenges of the current historical moment. This is coupled with insufficient problem-solving capacity, characterised by poor coordination and low efficiency (despite sufficient material and intellectual resources). This is related to the rise in political distrust of the citizenry toward political and other elites at both the national and EU levels, which is associated with the rise of Euroscepticism. One should also add a relatively weak awareness of a common

European identity, not only among ordinary citizens but also among elites. It can be stated that political and other elites bear the bulk of responsibility for the legitimacy crisis in Europe.

To overcome the legitimacy crisis of European democracy, it is necessary to strike a balance between national sovereignty and the implementation of common political solutions at the Union's level. This is a delicate task, since it cannot be achieved once and for all, but must be established again and again. However, this must not occur through the majorisation and centralisation of decision-making. This would only mean further erosion of legitimacy. It is necessary to increase capacity to resolve key EU problems efficiently and successfully, protecting the European way of life without additional bureaucratisation. On the contrary, it is essential to reduce the scope of regulation, limiting it to matters where the intervention of European institutions is vital. The legitimacy of European democracy and the strengthening of a common European identity, without which it cannot exist, must not be at the expense of national and other existing forms of identification.

2 How strong is European democracy?

We often hear that European democracy is in crisis (Armingeon & Guthmann, 2014; Kriesi, 2020; Moises, 2019). One of the most common criticisms is its alleged elitism, claiming it is not representative enough and that ordinary citizens are largely excluded from decision-making on public matters. This is particularly applicable to political decision-making at the European Union level. Its leading representatives are said to be alienated from the lives and needs of ordinary people and therefore not acting in their interests.

However, it is essential to remember that the European Union is a *specific political entity* (Tomšič, 2012). It differs from other supranational organisations in that it is not simply about intergovernmental agreement on joint decisions. Since it has become more than just a common economic space of the countries of the so-called 'old continent', that is, it has become a supranational institutional entity with its own original powers, which is superior to its member states in certain vital areas, the question of the European political order has come to the fore. And with it, the question of European democracy. In the Western world, which is rooted in European spiritual heritage, democracy is one of its fundamental characteristics. Thus, the existence of democratic principles of political action, with the entire set of human rights and freedoms, is *a conditio sine qua non* for a country to become a member of the European Union. Therefore, if we consider that democracy must be established at the level of individual member states, it is almost self-evident that the Union as a whole must also take into account the fundamental democratic postulates in its operations.

However, when we discuss the essence of democracy, the situation becomes more complicated than it initially appears. Democracy as a political system is a complex phenomenon, significantly more so than any of its alternatives. According to O'Donnell (1998), polyarchy as a real democracy consists of three components based on three intellectual currents or traditions: democratism, which brings the concept of equality between people; liberalism, which brings the idea of rights that no authority may violate; and republicanism, which brings the concept of civic virtues and commitment to the public good. In this regard, the successful functioning of polyarchy requires a balance and complementarity among all three components, as the absence of any one of them would lead to significant deformations. Upon examining institutional solutions across various European countries, we can observe that, despite common democratic principles, distinct political systems exist. Some use a majority system, while others use a proportional system; some use a parliamentary system to exercise power, and some (though much less frequently) use a system in which the president has relatively large executive powers. So, how can we create a unified democratic model that could function successfully at the European Union level?

When it comes to the functioning of the European Union, its critics often highlight the alleged so-called 'democratic deficit' (Haller, 2008; Norton 1996; Follesdal & Hix, 2006)). This means that the most important decisions at the Union level are made in narrow and closed circles by the elite. Therefore, ordinary citizens have no special influence on them. In doing so, they advocate introducing mechanisms that would enable more direct citizen participation. Despite the justification of certain accusations of the 'elitist' nature of the decision-making process at the European level (Dahl 1999; Wood, 2002), it is necessary to recognise that the Union cannot operate in the same manner as its member states, as its legitimising basis differs. In order for European democracy to operate in a more participatory way, what Weiler (1996; 2002) calls a 'European demos' is needed, that is, a European citizen body that would share a sense of common belonging, which would be the basis for the formation of a common civil sphere and public space at the level of this supranational association. However, at present, we can hardly speak of such a unified European citizen body. Most citizens of the EU Member States still feel themselves to be members of their own nation and state first and foremost, and Europeans only much later (although these two are by no means contradictory). In such circumstances, the introduction of more direct decision-making at the European level and the introduction of the majority principle in the sense of 'one citizen, one vote' would lead to the dominance of the most numerous countries/nations, also to the detriment of the smaller ones.

In the light of the above, we may ask, is European democracy actually in crisis? It is undoubtedly challenging to speak of its crisis in the sense of its existence being threatened, for example, that some anti-democratic alternatives could, in the short or even medium term, replace the democratic order. Most Europeans still support representative democracy as the most appropriate form of government (at least for citizens of the

European Union). This is what most research conducted over the last two decades has shown.[2] There are, however, certain ambiguities, discrepancies and contradictions. According to some surveys, a significant portion of the population also supports alternative variants, such as the rule of a strong leader or the rule of experts, which are inconsistent with the principles of liberal democracy (Adam & Tomšič, 2019). However, in general, we cannot speak of the growing anti-democratic political climate in Europe.

However, different assessments indicate that democratic backsliding is occurring in some European countries (Greskovits, 2015). We are allegedly witnessing the rise of so-called illiberal democracy, which sometimes has elements of authoritarianism. This is said to lead to a marked concentration of power in the hands of the executive branch of government, which is systematically weakening those institutions that serve to control powerholders. Here, the primary concern is the curtailing of judicial independence. Other strategically critical social subsystems, such as education and the media, are also 'under attack'. The authorities are attempting to bring the latter under their control through direct personnel interventions in public media and by supporting the creation of media conglomerates in the hands of businessmen connected to the authorities. These phenomena are primarily associated with 'new democracies' from Central and Eastern Europe. Among the members of the European Union, where the principles of liberal democracy are being undermined, Hungary is most often singled out during the rule of the Fidesz party and its leader, Viktor Orbán.[3] Similar accusations were also levelled at Poland during the previous government led by the Law and Justice party. The situation in Southeast Europe is even more problematic, especially in Serbia under President Aleksandar Vučić.

However, it is worth noting that assessments of a country's democracy, which often appear in political and media discourse, can be politically motivated. We can observe that stricter criteria are used to judge the former communist countries of Central and Eastern Europe.[4] We can even speak of double standards. Sometimes, more important than the problematic nature of the actions of those in power is the political 'colour' of the officials who carry them out.[5] Bias in assessing the state of democracy does not contribute to its improvement; rather, it creates tensions and reduces political trust in the European space.

3 Internal and external threats to political stability in Europe

The importance of Europe in international relations has declined significantly over the past few decades. Here, we refer to the European Union as the central institutional entity of the 'old continent' and the countries closely associated with it (which still includes the recently departed United Kingdom). The individual European powers that once ruled large colonial empires have long since ceased to play a leading role in the world. However, the international 'weight' of the Union is significantly less than one might assume based on its economic, scientific and intellectual potential. Therefore, not only is

it unable to play a relevant role in solving key global problems and conflicts, even if they are on its doorstep, as in the case of the war in Ukraine.

Moreover, Europe is itself exposed to threats from authoritarian centres of power. This is clearly evident in Russia's relationship with Putin. It is thus downright absurd that, in terms of security, it is held in check by a country that is in no way a match for it economically compared to the Union, regardless of its territorial extent (since its economy is on a par with Italy in terms of size). However, the economic power of the Union in no way corresponds to its military power. With authoritarian leaders like Putin, the latter is what counts above all. Therefore, in countering the imperial ambitions of Putin's Russia, it must still rely on the USA's help.

However, Russia does not pose the main long-term threat to Europe. It poses a security threat, as it conducts military operations on its eastern borders, but is not competitive with it in economic and technological terms (with the partial exception of the military industry). The main long-term threat is China, which is experiencing a tremendous economic upswing and, in certain areas, has significantly overtaken Europe in terms of technology (for example, Artificial Intelligence). In accordance with this, in recent years, its geopolitical influence has also expanded significantly, especially in the so-called Global South. However, China's economic and technological breakthrough came largely thanks to Europeans (and to a lesser extent, Americans). Its power is growing because they have been enabled to do so. Western economic and political elites, short-sightedly, abandoned certain important industrial sectors and shifted production to the Third World (primarily to China). Then they sold many high-tech companies to the Chinese (who then copied their technological solutions). Then there is also the ecological obsession of the European political elite, which, encouraged by a multitude of climate and similar activists, is literally destroying entire economic sectors with numerous restrictions and tax burdens. This is most evident in the automotive industry, where Europe was once a leader but has now lost that advantage due to numerous obstacles.[6] Due to multiple burdens, even agriculture, on which the population depends for its food, is under attack.

Undemocratic global centres of power realise their ambitions both using military force (mainly Russia) and indirectly, through the propagation of their own narratives. They often resort to disinformation, primarily distributed through social networks and web media (Splidsboel Hansen, 2017). They also spread their political visions by creating allies in European countries. The targets are mainly politically and socially unstable countries from the Eastern and South-eastern outskirts of the European Union. They most often find allies on the far right and far left, as both oppose the system of liberal democracy, and they are united with the undemocratic superpowers by collectivism and support for authoritarian rule.

This brings us to the internal factors destabilising the democratic order in Europe. It is about the rise of populism and various forms of radicalism. The two cannot be equated.

Populism is a multifaceted phenomenon that can be associated with different aspects of political life (Tomšič, 2024). It can be understood as an ideology, albeit a diverse, incoherent and fluid one (Riedel, 2017). Nevertheless, some principles are common to its different variants. Mudde (2004, p. 534) defines populism as "an ideology that ultimately divides society into two homogeneous and antagonistic groups, the 'pure people' versus the 'corrupt elite', and which argues that politics should be an expression of the general will of the people (volonté générale)." It can be seen as a form of political conduct. This refers primarily to the type of leadership within a particular political entity (party, movement), especially the relationship between the leader and his followers (Soare, 2017). Political behaviour is related to political strategy (Weyland, 2017), the essence of which is to mobilise citizen support to achieve populist goals. In addition, populism can be understood as a political style, specifically its communication style (Jagers & Walgrave 2007; Moffit & Torney 2014; Krämer, 2017). Populist messaging is characterised by unambiguous, straightforward sentences, a black-and-white portrayal of society, and the offer of palatable policy solutions. It gives a distinct advantage to playing on people's emotions rather than offering a rational explanation of complex social problems.

Populism is often seen as problematic from the perspective of democratic development. Many authors believe that it rejects some aspects of its institutional arrangement. The most common examples of this are the rejection of pluralism, the undermining of the rule of law, and negative attitudes towards various social (ethnic, religious, etc.) minorities (Albertazzi & McDonnell, 2008; Mudde & Kaltwasser, 2017; Mueller, 2016; Mounkm 2018; Urbinati, 2019). This is especially true for the 'new democracies' from Eastern and Central Europe, as populism there is said to be particularly exclusivist, and is therefore more likely than that in Western Europe to favour the introduction of 'illiberal democracy' or even outright authoritarianism (Bugarič, 2019; Halmai, 2019; 2024). Given that most European populist parties and movements are Eurosceptic, many see the rise of populism as a serious threat to the European Union's continued existence. It is also problematic that many populist leaders show more or less open sympathies for autocratic regimes, such as Putin's in Russia.

However, while populism can be problematic in specific contexts, particularly in relation to authoritarian leaders, it is not inherently anti-democratic. Similarly, the vast majority of European populists, while critical of the European Union's functioning, do not advocate leaving it. Ideological radicalism, whether in the form of either right-wing or left-wing extremism, is not necessarily populist. However, both are very present and, at specific points in the situation, are in the same positions, for example, regarding support for Russia and its expansionism. Both oppose the fundamental postulates of the liberal democratic order. Nevertheless, the popularity of both is not only an expression of anti-democratic sentiments among Europeans, but also, to a greater extent, a reflection of dissatisfaction with the functioning of democratic institutions.

4 Reasons for the legitimacy crisis

A profound change in the constitution of political space that has been taking place in contemporary democracies in the last couple of decades, which particularly applies to the developments in terms of organisational structure of political parties and their mode of functioning as well as the change in mechanisms of mobilisation of political support and establishing a link between parties and their constituencies (Tomšič, 2024). The typical party structure, whose core was one strong left-of-centre and one strong right-of-centre party, no longer exists in many places. We are faced with the rise of new parties, many of which have a distinctly personalised character (the leader is the key, if not the only element of their politics). This has destabilised the political space in many European countries.

There is a widespread perception of the ineffectiveness of democratic political institutions and of the *lack of leadership* — i.e., the incompetence and irresponsibility of established political elites — at both the national and European levels (Adam & Tomšič, 2020). This was especially evident in crises. First, we witnessed the poor handling of the 2008 financial crisis, when European institutions were unable to respond promptly to the high levels of indebtedness and economic weakness in some member states, particularly Greece. These members had obvious problems with financial discipline and with ensuring financial control. However, the deception of some of the Union's leading countries was revealed, and they knowingly allowed it, as their private banks (which lent money to these countries) also benefited from it (Mahnkopf, 2012). The irresponsibility of the business and political elites, who were primarily responsible for the crisis through their speculative activities, came to light.

The performance worsened even further later, particularly with the great migrant crisis of 2015. At that time, it became apparent that the European Union had no plans to effectively address the influx of people from its near and far surroundings who wanted to settle within its borders. The migration management system, as envisaged by the so-called Dublin Regulation,[7] *de facto* collapsed, as it proved unworkable under the given conditions, with some member states (Poland, Hungary, Czechia) explicitly refusing to implement it. Each country at whose borders the migrants appeared had to find their way. This has led to tensions and frustration among both migrants and the local population. The approaches of the member states were opposed: one (Germany) invited migrants (especially those from Syria, where a civil war was raging at the time). In contrast, the others (Hungary) erected fences on their borders. To this, we can add that the integration of migrants, especially those from Muslim countries, has failed chiefly, which is reflected in many social problems, such as the low level of education and the high level of unemployment in these communities. The migrant crisis brought security problems like an increase in crime and the rise of terrorism (particularly in 2015 and 2016),[8] which created not only resistance to migrants but also feelings of threat among people. Many saw the reason for this in the incompetence of the ruling elites.

In accordance with the above, one can speak of an *insufficient problem-solving capacity* of European institutions. This is not a result of a shortage of material, financial or intellectual resources. The European Union has enough of these at its disposal. It is often a lack of coordination between different stakeholders (which was clearly seen in resolving the migrant crisis). However, this is not just a matter of weak organisation. It is often linked to a lack of political will to tackle the most pressing societal issue.[9]

However, it is not only the actions of established elites that contribute to growing dissatisfaction among citizens. Their (alleged) *value orientations* are also the target of criticism and increasingly rejected by them. We are talking about certain ideologies that are advocated by at least part of the elite (Tomšič, 2024). This refers to neoliberalism, which represents the ideological basis of globalisation – especially in the economic field (Cayla, 2021). The latter rejects the need to maintain social equality in its distinct individualism. It advocates the deregulation of financial and other relations, thereby reducing the role and importance of the (national) state in ensuring social well-being. As a result, this also means neglecting the importance of collective forms of belonging as a framework for maintaining social cohesiveness.

However, the most common target of populists is multiculturalism. It can be understood in two ways: as a political strategy (how to regulate relations between culturally distinct entities, such as ethnic and religious communities) and as an ideology (promoting the positive aspects of intercultural differences). Here we focus on the second aspect, since most criticism is directed at it. As an ideology, multiculturalism holds that cultural diversity is inherently positive. Its fundamental proposition is that individual culturally specific communities should have the right and opportunity to cultivate their own values, customs and lifestyles (Heywood, 2012). It advocates equality between these communities, with an emphasis on the rights of minority communities compared to the cultural majority (for example, immigrant communities in European societies). Multiculturalism is associated with the rise of post-materialist values (Inglehart, 1979; 1990). It is strongly supported by members of the academic community and other public opinion leaders, as well as the left-liberal part of the political elite. Some take it for granted. However, this ideology downplays the significance of (excessive) cultural differences and their potentially problematic impact on society's functioning (Tomšič, 2017). With the migrant crisis and the problems it brought, these ideas have encountered widespread opposition across Europe. Many have blamed (part of) the elite's multiculturalism for the poor resolution of migration-related problems.

Lack of leadership, low problem-solving capacity, and other forms of misbehaviour by established political parties, such as ideologisation, clientelism, nepotism, and corruption, lead to increasing *political distrust* (Cabada & Tomšič, 2016). The trend of declining confidence in political institutions is evident in many Western democracies and is even more pronounced in the new democracies in Central and Eastern Europe. Among them,

political parties are among the most distrusted (Makarovič & Tomšič, 2015). There is also an increasing gap in representation between parties and electorates in many democracies (Keman, 2017). In such an atmosphere, the legitimacy of the existing institutional order can be quickly threatened.[10] Moreover, opponents of democracy, both external and internal (often acting in concert), will try to exploit this legitimacy crisis, associated with low political confidence, to advance their own political agenda.

The legitimacy problems with the European political order are also linked to the relatively weak European identity (Tomšič, 2017). As mentioned, most citizens still place their national affiliation first, well ahead of their European one. Many also consider politics at the European level to be something quite distant, having little to do with their interests. This is also reflected in the turnout in the elections to the European Parliament, which is (in many countries, particularly from the Eastern flank of the European Union) significantly lower than in domestic parliamentary elections (although it has increased since 2014). Since there is no strong sense of common belonging, there would also be some 'pre-emptive consent' regarding the legitimacy of the existing European political architecture.

5 Improving European governance

The European Union represents a special case among supranational associations, since it aims to transcend mere economic integration or any other specified integration. It thus seeks to establish a joint institutional/political system regulating the most critical functional areas by setting the basic rules and standards for their operations. We generally speak about a political entity that is more integrated than a confederation but less than a federation (Siedentop, 2000). However, the Union's political trajectory remains uncertain.

To address the crisis of European democracy, it is essential to enhance the existing system of democratic governance. While increasing the efficiency of European institutions is necessary, this must not come at the cost of diminishing the sovereignty of the member states. Maintaining a balance between the competencies of both entities is particularly challenging. Decision-making on the Union's common matters should be conducted swiftly, yet it is crucial to ensure that the interests of individual member states are not marginalised or overlooked. Majoritarianism and centralisation of decision-making must be avoided. The institutions of the European Union must cooperate with the Member States but avoid interference in their internal affairs.[11]

It will be necessary to clearly identify which areas are so vital for the effective functioning of the Union that they require unified regulation. Conversely, those areas that do not fall into this category should remain under the jurisdiction of individual countries. This approach can be characterised as a form of 'selective interventionism'. Institutions of the Union need to improve their capacities to tackle the key problems of this supranational

political entity effectively. We have in mind issues such as illegal migration, terrorism, threats posed by global authoritarian centres of power, as well as technological development and the enhancement of European economies' competitiveness. They need to be able to protect the European way of life and defend European interests in the international environment in an effective way.

However, in strengthening the capacities of European institutions, excessive regulation must be avoided. On the contrary, de-bureaucratisation is needed, that is, a reduction in the volume of administrative procedures that often stifle creativity in economic and other areas. A thoughtful and pragmatic approach is required when designing measures, while avoiding ideologisation.

Contemporary democracy has developed within the nation-state context, where national identity serves as a common integrative framework for citizens. Similarly, democracy at the European Union level also needs some European identity as the basis of a political community and a unified democratic entity. However, there is a relevant question about the essence of European identity. Pluralism, as one of the central features of European culture, is the main reason for the lack of consensus about the features that European peoples share. This was clearly demonstrated in the dilemma over whether to mention the role of Christianity in the preamble of the European Constitution. The positions of the Union Member States on this issue were very divided (at that time, they adopted a compromise formulation that emphasised the importance of religious heritage). The European space comprises different ethnic or religious communities with identities which cannot be united into a single cultural category (for example, by means of a 'melting pot' mechanism, as established in the United States of America). The creation of some 'European nation' is – at least in the medium term – a utopia. Therefore, European unity and solidarity can be based solely on respect for individual and collective differences.

For the European institutional order to achieve 'unity in diversity', a permanent dialogue between the European national communities, as they have formed over the centuries, each with its own tradition and historical memory, would be necessary. This dialogue must take place on an equal basis. In the meantime, it is essential to strengthen awareness of common belonging as the basis of the creation of 'European demos'. There should be self-reflection and even critical distance toward the darker sides of European history, without sacrificing self-confidence and pride in the cultural (and other) achievements of European/Western civilisation.

6 Conclusion

Events in today's world prove that we are far from the 'end of history', that is, the global dominance of the Western type of social order, as Fukuyama (1992) optimistically, not to say naively, imagined in the early 1990s. Parliamentary democracy is by no means a generally accepted ideal. Those global powers that openly undermine it are gaining

strength. Moreover, the power of the West as the bearer of this order is decreasing. This is especially true for Europe, which is becoming increasingly dominant in international relations of power.

The primary reasons for Europe's decline in global power and influence are predominantly ideological and political. They do not originate in the external environment or in global undemocratic centres of power but are the product of internal developments in Western societies. Misguided strategic orientations, neglect of key areas such as defence, and the decline in economic competitiveness due to ill-considered measures stemming from ideological illusions have weakened the position of the 'old continent.' This has been significantly contributed to by the inefficiency of established elites and their alienation from the real problems that burden ordinary people.

It would be difficult to say that European democracy is under threat or that its system lacks legitimacy. However, its future is still undetermined. There is also no consensus on further political development in Europe. Currently, the most prominent are two mutually contradictory and exclusive visions. The first is the integralist vision, which assumes the centralisation of decision-making and the strengthening of the powers of European institutions. The second is the sovereigntist vision, which assumes that the European Union is already too integrated and therefore advocates loosening ties and transferring key powers to the member states. Both visions are problematic. Sovereigntists do not take into account that certain problems are so complex that they require joint solutions, since no European state has the capacity to address them. Integralists, however, do not understand that excessive centralisation would lead to the dominance of some member states over others, thereby causing conflicts that could lead to the collapse of the Union. The power of the latter as a whole and the power of its members are not mutually exclusive. However, it is necessary to allocate responsibilities between the European and national (and also local) levels of governance thoughtfully. The European Union is not doomed, as Zielonka (2014) wondered in his provocatively titled book. However, it will have to face the challenges of modern times more effectively, while considering the interests of its various stakeholders to the greatest extent possible.

Notes:

[1] In this context, Beetham (1991) speaks about three dimensions of legitimacy. The first refers to acceptance of the rules in the sense of acknowledging their legal validity; the second represents justification of the rules in the sense of common beliefs (i.e. a value consensus on the basic principles that are in place in society). In contrast, the third refers to legitimation of the rules by abiding by them.

[2] See, for example, European Values Survey rounds in 2008 and 2017,6 the World Values Survey rounds in 2000-2005 and 2010-2014; the Pew Research Center in 2017; or data from the round 6 and round 8 of the European Social Survey.

[3] This is also highlighted by official European Union documents such as the Commission's Rule of Law Report.

[4] As mentioned, Hungary is often singled out as the EU member state with the most violations of democratic standards. However, no one has been imprisoned there for political activity, unlike Spain, where some of the most active supporters of Catalan independence have been sentenced to prison terms. However, this has been met with relatively lukewarm criticism.

[5] A typical example is the situation in Slovenia. The previous government of Janez Janša, which was predominantly right-wing, was frequently accused of political recruitment and interference in the media's independence. Criticism also came from within European institutions. However, when the current government of Robert Golob implemented the same or even more drastic interventions (it even changed the law on the public broadcasting company to allow it to install its loyalists into a new management, which illegally removed certain 'politically inappropriate' editorial staff and news), there were significantly fewer critics.

[6] An example of this is the decision to ban the production of cars with internal combustion engines by 2035. This will most likely prove unfeasible in practice. However, it has caused significant damage to the European automotive industry.

[7] The EU Dublin Regulation is an EU law on the rules about which country should assess your application for international protection. It applies to Dublin countries, which include all the countries in the EU, plus Iceland, Switzerland, Norway and Liechtenstein. Citizens Information, 3.10.2025, https://www.citizensinformation.ie/en/moving-country/asylum-seekers-and-refugees/the-asylum-process-in-ireland/dublin-convention/

[8] See, for example, Riham Alkousaa, "Violent crime rises in Germany and is attributed to refugees," Reuters, 3. 1. 2018
https://www.reuters.com/article/us-europe-migrants-germany-crime-idUSKBN1ES16J

[9] This is clearly evident in the area of defence and security capabilities, where Europe is relatively weak, especially when compared to its economic potential. The extremely low level of investment in this area has mainly been politically determined. Although after the Russian invasion of Ukraine, the share of defence spending in GDP increased in general in European NATO member states, there are still seven of them that spend less than 2% and only four of them spend more than 3%. https://www.bbc.com/news/world-44717074.

[10] This reflects a shift toward the European Union in recent years, which some scholars describe as 'constraining dissensus' (Down & Wilson 2008; Hooghe & Marks 2009). This refers to increasing polarisation over matters in the European Union across several of its member countries, and to the rise of criticism, or even outright rejection, of European integration (Makarovič & Tomšič, 2018). The latter is reflected in the increase in votes for anti-EU parties on both the left and the right of the political spectrum.

[11] An example of a highly likely interference in the internal affairs of a member state was the visit of European Commission Vice-President Vera Jourova to Slovenia in March 2023, during which she also met with the President of the Slovenian Constitutional Court, Matej Accetto. The Constitutional Court had previously suspended the law governing the Slovenian public broadcaster, which would have allowed the replacement of its leadership, a move the government of Robert Golob considered politically disloyal. Shortly after this visit, however, the President of the Court – and another judge – changed their minds, and the court lifted the suspension of the law, allowing the government to appoint its supporters to the top positions. This raised legitimate suspicions that the change was due to pressure from Vice-President Jourova, who is a political ally of Prime Minister Golob. She and Accetto denied that they had discussed the law. However, the third point of the memo, prepared for Jourova's visit (named What we want from Accetto), which was revealed by the Commission only after the intervention of the EU Court of Justice at the request of the

Member of the European Parliament Milan Zver, is Jourova's instruction to "find an opportunity to check the views of the President of the Constitutional Court regarding the new RTV Slovenia law". It is therefore very difficult to believe that the discussion about the law, which was at that time suspended and under constitutional review and thus influencing the court's decision, really did not occur.

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Aligning Stakeholder Governance with Industry 5.0: Enablers and Barriers in Rural Bioeconomy Transformation

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Abstract Integrating bioeconomy principles into the emerging Industry 5.0 agenda is presented as a way to reconcile competitiveness with sustainability, resilience, and human-centric development. This chapter examines how stakeholder governance in rural regions enables or constrains such transformations, with a particular focus on the roles of governance enablers and barriers in the relevance of territorial/local self-government. Conceptually, it links debates on stakeholder governance, the bioeconomy, and Industry 5.0, arguing that rural bioeconomy pathways are shaped by the interplay of institutions, networks, and cognitive frames, rather than technology or markets alone. This article examines how stakeholder governance arrangements enable or constrain rural bioeconomy transformation across three case regions (Slovenia, Montenegro, and Baden-Württemberg). Using Industry 5.0 as a normative frame and SOFIA as an analytical coding approach, it identifies key institutional, network, and cognitive enablers and barriers, and derives governance-relevant implications for territorial development.

Keywords: • bioeconomy • Industry 5.0 • stakeholder governance • rural development • circular economy • multi-level governance

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https://doi.org/10.4335/2026.2.8 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

The governance of sustainability transitions relies on complex interactions among stakeholders, particularly in the context of rural bioeconomy development. This chapter discusses the crucial role of stakeholder governance in facilitating or constraining the goals of Industry 5.0, emphasizing that successful integration primarily requires effective governance arrangements. The argument posits that aligning rural bioeconomy strategies with the Industry 5.0 paradigm hinges less on mere technological advancements and more on fostering collaboration, alleviating structural inequities, and integrating human-centric values into governing processes.

Industry 5.0 represents a paradigm shift toward a more human-centric, sustainable approach in industrial environments. It emphasizes the collaboration of human intelligence and machine capabilities, aiming to create a balance between economic growth, societal well-being, and environmental stewardship. Furthermore, it is increasingly recognized more as a conceptual framework rather than solely a technological paradigm (Noori et al. 2020). Besides, it emphasizes human engagement alongside advanced technologies, striving for increased productivity while also pursuing social equity and environmental sustainability. From a governance perspective, Industry 5.0 functions less as an innovation policy and more as a normative benchmark against which institutional arrangements, stakeholder participation, and coordination capacities can be evaluated.

However, the fragmentation in current literature limits the connections drawn between governance structures and the achievement of Industry 5.0 goals (de Graaf, 2016; Potočan et al., 2021). Europe's strategy on Industry 5.0 is framed within broader initiatives, such as the European Green Deal and the New Industrial Strategy, which aim to promote sustainable practices across various sectors (Abozaid, 2024; Gudz et al., 2021). The European Green Deal is particularly significant as it strives to transform the EU's economy, addressing climate change by enhancing the EU's energy efficiency and environmental sustainability ambitions (Abozaid, 2024). Moreover, the New Industrial Strategy emphasizes bolstering Europe's industrial ecosystem to ensure its global competitiveness while transitioning towards a climate-neutral economy (Gudz et al., 2021). Key initiatives under this strategy include the European Raw Materials Alliance, which underlines the crucial role of raw materials in ensuring sustainable industrial growth and fostering circular economies (Belov, 2020).

Stakeholder governance within the Industry 5.0 framework is critical for driving initiatives that are socially responsible, economically viable, and environmentally sustainable. The EU aims to foster a collaborative environment conducive to innovation by empowering various stakeholders, including businesses, governmental entities, and civil society (Bingham et al., 2005; Roman et al., 2020). Notably, incorporating diverse

perspectives into decision-making processes promotes transparency, builds public trust, and fosters inclusivity, all of which are critical for achieving long-term multilateral goals (Roman et al., 2020). To fully realize the potential of Industry 5.0, coherent policy frameworks are required that align stakeholders' motivations and expectations (Gudz et al., 2021).

From a sociopolitical standpoint, the participation of diverse stakeholders is critical for fostering the values of transparency, trust, and inclusivity that are required for Industry 5.0 to be implemented successfully. Historical examples demonstrate that governance frameworks, such as co-management systems, can facilitate collaborative engagement, leading to improved outcomes across multiple sectors (Vignieri, 2020). Political dynamics and established interests, on the other hand, may act as impediments to effective governance, stymying progress toward comprehensive industry reform. The challenge lies in transitioning from a theoretical understanding of stakeholder interactions to a practical assessment of their impact on policy implementation and social equity (Kolugala et al., 2022)

Stakeholder governance provides a framework for collaborative decision-making, which is crucial for addressing the complex challenges associated with sustainability transitions. Schultz et al. argue that stakeholder governance goes beyond simple stakeholder relationships, advocating for a systemic approach to catalyze collaborative efforts among diverse entities—an essential component for transitioning to a circular economy aligned with Industry 5.0 goals. Furthermore, Borchardt et al. emphasize that the transformation anticipated by Industry 5.0 goes beyond technological innovation, encompassing holistic business model re-evaluations that necessitate inclusive stakeholder engagement and governance structures that promote social resilience and human-centric development (Borchardt et al., 2022).

Aligning bioeconomic strategies with such governance frameworks in rural areas can help to mitigate potential conflicts caused by competing interests in resource utilization (Ratner et al., 2013). Inclusive governance processes in the promotion of bioeconomy can reduce socio-environmental tensions, implying that stakeholder engagement is critical for achieving equitable outcomes. Bezama et al. argue that the effectiveness of bioeconomy initiatives is inextricably linked to regional stakeholder roles, making stakeholder governance critical for long-term rural development (Bezama et al., 2019).

Despite its potential benefits, stakeholder governance faces challenges. The literature highlights gaps in the practical application of collaborative governance principles. According to Ansell and Gash (2008), the success of collaborative governance engagements can be influenced by various contextual factors, including stakeholder trust and the ability to foster a consensus-oriented decision-making environment. This

complexity implies that simply establishing governance frameworks is insufficient; cultivating cooperative relationships among stakeholders is equally critical.

Furthermore, the concept of fairness is critical in negotiations with multiple stakeholders. Hennig- Hennig-Schmidt et al. (2024) emphasize the importance of fairness in shaping cooperative behaviors in resource management and policy implementation. However, it is unclear how these principles can be applied universally across diverse settings, particularly in rural contexts marked by significant economic and social disparities.

To effectively bridge the gap between rural bioeconomy strategies and Industry 5.0 paradigms, governance arrangements must prioritise long-term collaborative frameworks. This includes integrating local knowledge and stakeholder expertise, as well as ensuring that governance designs are adaptable to changing socioeconomic conditions (De Besi & McCormick, 2015). Tapaninaho and Heikkinen argue that sustainability-oriented business models should be tailored with specific attention to stakeholder dynamics, emphasizing the importance of incorporating fairness and equity into economic structures (Tapaninaho & Heikkinen, 2022).

Madzik et al., (2025) suggest that participatory mechanisms can empower local stakeholders and promote resilience and sustainability in rural bioeconomic practices. The human-centric focus of Industry 5.0 emphasizes the importance of incorporating diverse stakeholder perspectives for inclusive technological transitions that benefit rural communities (Potočan et al., 2021).

Moreover, developing strategies that recognize the complexity of stakeholder dynamics is imperative. Understanding how governance mechanisms influence corporate behavior and industry standards can help bridge existing gaps in the literature, ultimately steering operational strategies toward more sustainable practices (Albareda et al., 2008; Jamali et al., 2008). Addressing regulatory complexities associated with corporate social responsibility, in particular, presents an opportunity to align industry practices with the fundamental principles of Industry 5.0 (Han, 2019).

Effective stakeholder governance not only promotes compliance with established norms but also enhances the capacity of industrial sectors to adapt to emerging challenges (D. Zhang & He, 2022). This adaptability is critical in the context of sustainability, where stakeholder engagement and collaboration can spark innovation and generate mutual benefits.

Europe's overarching strategy for Industry 5.0 aims to integrate technological innovation with a human-centric approach, supported by effective stakeholder governance. This strategic direction aligns with the EU's vision of sustainability and competitiveness, stressing the importance of coordinated governance systems. As the EU continues to

refine its strategies and engage diverse stakeholders, it stands to cultivate an industrial environment that thrives on innovation while prioritizing societal and environmental responsibilities.

Empirically, the chapter examines three European case regions—Slovenia, Montenegro, and Baden-Württemberg—representing different institutional contexts, governance capacities, and stages of bioeconomy development. Using the SOFIA (Social Fields Approach) analytical framework, the study combines a structured review of grey literature with expert discussions to identify key governance enablers and barriers across three analytical categories: institutions, networks, and cognitive frames. This analytical design enables a systematic examination of how stakeholder dynamics and regulatory frameworks shape the interaction between multi-level governance structures and Industry 5.0 normative objectives in rural bioeconomy development.

Against this background, Industry 5.0 is employed in this chapter not as a technological roadmap but as a normative governance framework that allows us to evaluate how multi-level stakeholder arrangements enable or constrain human-centric, sustainable, and resilient rural bioeconomy transitions. The chapter addresses the following research question: *What key enablers and barriers in multi-level stakeholder governance shape the implementation of the rural bioeconomy within the framework of Industry 5.0 normative guidelines?*

Answering this question, the chapter contributes to current debates on the governance of sustainability transitions by explicitly linking stakeholder governance theory, rural bioeconomy development, and the Industry 5.0 paradigm. We will try to demonstrate that aligning rural bioeconomy strategies with Industry 5.0 is less a matter of technological innovation than of designing governance arrangements capable of sustaining cooperation, reducing structural inequalities, and embedding human-centric values in territorial development processes.

2 Literature overview
Stakeholder Governance and its potentials for understanding transitions in the bioeconomy

At the heart of contemporary debates on sustainable transformation lies the question of how diverse interests can be aligned towards shared societal goals. Stakeholder governance provides one line of responses, bringing into focus the interplay between industry, policymakers, researchers, and citizens, emphasising collaborative responsibility in shaping economic and technological pathways. By framing governance as a dynamic negotiation among actors (Westin & Montgomerie, 2024) with different expectations, resources, and values (O'Connor & Shahwan, 2025). This approach offers a foundation for understanding how emerging models, such as the bioeconomy and

Industry 5.0, can be steered towards outcomes that serve both environmental integrity and social well-being.

Following the definitions, stakeholder governance is, in general, understood as the set of formal and informal mechanisms (among those contracts, norms, and organizational designs and networks) that organizations use to manage relationships with multiple stakeholders, resolve collective action problems in joint value creation, and sustain cooperation by ensuring perceived fairness among stakeholders beyond shareholders alone. The theories that encompass the term itself are not new, as the foundational work was published in the 1980s, with *Strategic Management: A Stakeholder Approach by* R. Edward Freeman. The work introduced the concept of organisations managing relationships with all groups affected by their activities. Attention shifted from shareholder primacy to broader accountability (Freeman, 1984). Jumping forward, as his work was left aside, until some 15-10 years ago, for more economic theories (Bridoux and Stoelhorst 2022) a stakeholder turn occurred. The stakeholder perspective has been adopted by numerous authors in recent years (e.g. Barney, 2018; Klein et al., 2012; Zollo et al., 2018). It was in 2022, Flore Bridoux and J.W. Stoelhorst advanced stakeholder governance as a distinct theoretical framework. They emphasised how governance resolves collective action problems in joint value creation via fair formal and informal contracts that sustain stakeholder cooperation (Bridoux & Stoelhorst, 2022). In their recent work, they identify three complementary theoretical strands that collectively support the development of a renewed theory of strategic governance. The first rests on the argument that value creation and value capture can only be properly explained when the mutual dependence of stakeholders is placed at the centre of analysis. Stakeholders are engaged in a dual process: they collaborate in generating value, yet simultaneously strive for its distribution (Brandenburger & Stuart Jr., 1996). The second strand highlights that human behaviour is shaped not only by self-interest but also by social preferences and moral sentiments. This is crucial, as interdependent stakeholders create value largely by addressing collective action dilemmas (Bridoux & Stoelhorst, 2022), where the tension between individual benefits and collective interests is ever-present. The third strand involves viewing the firm as a nexus of both formal and informal contracts. This perspective has long been a foundational aspect of stakeholder theory (Jones, 1995). In this context, the contractual view presents the firm as a network of freely associating individuals who come together to create value collectively (Freeman & Phillips, 2002). Recent studies have investigated the role of stakeholder involvement in creating and sustaining value. These studies emphasise the intricacy of stakeholder contributions and their broader implications for different organisational structures. One key insight is that some stakeholders, situated outside the firm, beyond the traditional boundaries that strategy scholars usually define, often invest in firm-specific assets, which are vital for generating value (Bridoux & Stoelhorst, 2022). For example, Odziemkowska & Dorobantu (2021) explore the nature of contractual relationships between corporations and local communities. Another consideration is raised by Bacq & Aguilera (2022), who

highlight that the recipients of responsible innovation may include individuals who, in fact, have made minimal, if any, contributions to its development.

Stakeholder governance provides a valuable analytical lens for understanding transitions to the bioeconomy, as it highlights the interdependence of actors whose collaboration is essential for reshaping production and consumption systems centered on renewable biological resources. The concept of the bioeconomy has emerged as a transformative framework with the potential to address pressing global challenges, including climate change, resource scarcity, and economic sustainability. As societies grapple with the detrimental environmental impact of fossil fuel dependence and the urgent need to transition (Staffas et al., 2013) toward renewable resources, the bioeconomy offers a compelling vision for a more sustainable future (Mertens et al., 2019). However, as the researchers seem to agree upon the benefits and challenges posed by the new economic concept, in the literature, we can detect differences in naming the phenomenon. Wreford et al. (2019) list numerous such naming: "bioeconomy", "bio-based economy", and even "bio-based society" and "knowledge-based bioeconomy" (see also Mukhtarov et al., 2017; Scarlat et al., 2015). Overall, regardless of differences in naming, it seems researchers share the meaning as bioeconomy being a strategy to generate wealth while addressing environmental challenges through reducing and reintegrating waste streams, deriving new value from waste, and unlocking economic opportunities through advancements in science, design, and the development of production systems and resilient industries (see also Martinez de Arano et al., 2018). However, it was not always like this, as in the past, researchers associated the term with scientific and research activities centered on biotechnology (Wreford et al. 2019).

Following the definition European Commission, (2018a, p.1), "*The bioeconomy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services.1 To be successful, the European bioeconomy needs to have sustainability and circularity at its heart. This will drive the renewal of our industries, the modernisation of our primary production systems, the protection of the environment, and will enhance biodiversity*".

Understanding bioeconomy from the standpoint of stakeholder governance, we recognise the complementarity of knowledge, capabilities, and motivations dispersed across industry, research institutions, and public authorities. This approach can help us understand how coordinated action can accelerate the development of sustainable value chains (Uršič et al., 2024). Viewed through this lens, stakeholder governance not only

provides explanatory power for why certain bioeconomic initiatives gain traction but also points to pathways for fostering innovation ecosystems that support resilience, societal acceptance, and the broader goals associated with Industry 5.0. Building on these foundations, the transition towards a bioeconomy aligned with the principles of Industry 5.0 can be understood as a distinctly stakeholder-driven undertaking. Both fields rely on a complex web of relationships that connect research institutions, firms, regulators, and citizens, each contributing knowledge, resources, and expectations that influence the direction of innovation.

Because the shift towards renewable, circular production systems presents a series of collective action challenges (Fric et al., 2025), the governance dynamics and individual competences outlined above become particularly important (Fric et al., 2023). Trust, reciprocity, and shared purpose are essential for mobilising the cooperation needed to redesign value chains (Gangaliuc, 2022), also around biological resources, while embedding the human-centric ethos that Industry 5.0 promotes. The following sections of this chapter examine how these interactions influence the development of bio-based markets and impact the EU's broader sustainability objectives.

However, applying stakeholder governance to bioeconomy transitions also exposes significant shortcomings that must be acknowledged. While the rhetoric of collaboration and co-creation is widely invoked, the governance of bio-based innovation often remains shaped by power asymmetries, expertise disparities, and resource imbalances. Large industrial actors and scientific institutions typically exert disproportionate influence over strategic priorities, technological choices, and the framing of sustainability benefits, leaving smaller stakeholders—particularly local communities and civil society—limited scope to shape outcomes meaningfully. Moreover, the notion that broad stakeholder engagement automatically leads to socially desirable or environmentally robust transitions risks obscuring deeper structural tensions, such as competing land-use demands, economic lock-ins, and the political interests embedded within EU policy mechanisms. A critical reading, therefore, suggests that while stakeholder governance offers important conceptual tools, its practical application requires far more scrutiny if it is to support a genuinely just and sustainable bioeconomy rather than reinforce existing hierarchies under the guise of inclusivity. In this chapter, Industry 5.0 is employed as a normative framework for evaluating whether rural bioeconomy governance arrangements promote human-centricity, sustainability, resilience, and democratic legitimacy. The focus is therefore on how governance structures embed citizens and stakeholders in decision-making, rather than on market-formation enabling conditions.

Taken together, the literature on stakeholder governance and the bioeconomy suggests that the realization of Industry 5.0 principles depends less on technological availability and more on the quality of governance arrangements. Human-centricity, sustainability, and resilience—core elements of Industry 5.0—emerge as outcomes of how institutions

coordinate, how networks stabilise cooperation, and how actors cognitively frame bio-based transitions. This insight directly informs the analytical focus of the empirical analysis.

3 Industry 5.0 and its focus on Human-Centred futures – the potentials for bioeconomy

Industry 5.0 has been introduced by the European Commission as a complementary paradigm to Industry 4.0, explicitly reorienting industrial development towards human-centered, sustainable, and resilient futures (Breque et al., 2021; European Commission, 2018b). Rather than treating technological upgrading and automation as ends in themselves, Industry 5.0 frames industry as a provider of societal value, operating within universal boundaries and supporting high-quality work and social cohesion. In parallel, the renewed EU bioeconomy strategy conceptualizes the bioeconomy as a systemic transition towards the sustainable use of biological resources across sectors, emphasizing the linkages between the economy, society, and environment, as well as the importance of citizen and consumer engagement for legitimacy and the uptake of bio-based solutions (European Commission, 2018b). When these two agendas are read together, Industry 5.0 provides a normative and institutional framework for a human-centred bioeconomy, in which governance structures are co-shapers of production systems, regulatory expectations, and the cultural meanings attached to "bio-based" lifestyles. In the following sub-sections, we elaborate on six interrelated dimensions of this human-centred Industry 5.0 vision and its implications for the bioeconomy:

3.1 Human-centric innovation (Industry 5.0 puts humans at the center of innovation)

A key departure of Industry 5.0 from earlier industrial paradigms is its emphasis on humans – not technologies – occupying the central position in innovation processes. The European Commission explicitly frames Industry 5.0 as placing "the wellbeing of the worker at the centre of the production process", moving from shareholder-driven optimisation to broader stakeholder value (Berardo, 2023; Breque et al., 2021; Directorate-General for Research and Innovation, 2024). Academic work on Industry 5.0 similarly underscores a re-humanisation of industry, where human creativity, judgement, and ethical responsibility are complemented – rather than displaced – by advanced digital technologies and collaborative robots (Coelho et al., 2023).

In the context of the bioeconomy, this human-centric perspective implies that innovation in bio-based products and processes cannot be understood solely as a technological substitution of fossil-based inputs. Instead, it foregrounds users' values, everyday practices, and identities as structural components of innovation trajectories (Gaffey et al., 2021).

A human-centric Industry 5.0 approach thus requires participatory design methodologies, user-centred experimentation (e.g., living labs) and forms of social innovation that integrate local knowledge and cultural meanings into bio-based value chains, particularly in rural regions where bioeconomic transformations directly affect livelihoods and landscapes.

3.2 Sustainability and circularity (Industry 5.0 demands: regenerative processes, bio-based circularity, sustainable material cycles)

Industry 5.0 explicitly links industrial competitiveness to sustainability and circularity, arguing that future prosperity depends on production systems that respect planetary boundaries and contribute to climate neutrality, biodiversity protection, and resource efficiency (Breque et al., 2021; ESIR, 2022).

The updated EU bioeconomy strategy aligns with this view by promoting a sustainable and circular bioeconomy, in which biomass production, processing, consumption, and end-of-life management are organised as regenerative cycles rather than linear chains (European Commission, 2018b).

Theoretically, the integration of Industry 5.0 and bioeconomy debates reinforces a shift from "weak" to "strong" sustainability: the goal is not merely to increase the share of bio-based materials, but to restructure socio-technical systems so that material and energy flows are reduced, circulated, and socially embedded. Recent work on the circular economy has highlighted tensions between efficiency-oriented, technocratic interpretations of circularity and more systemic, justice-oriented approaches that foreground the power, culture, and symbolic dimensions of change (Korhonen et al., 2018; Uršič et al., 2024).

Industry 5.0 strengthens the latter by insisting that circularity must generate co-benefits for workers, communities – for example, by supporting quality jobs in bio-based sectors, ensuring safe and healthy working environments in biomass processing, and addressing distributional effects along supply chains. Sustainability and circularity are increasingly mediated through labels, standards, narratives, and digital information tools. Bio-based products compete not only on price and performance, but also on their ability to credibly demonstrate lower environmental footprints and contributions to local circular ecosystems. Life-cycle assessment (LCA), eco-design, and extended producer responsibility schemes become critical infrastructural elements in the human-centred bioeconomy, translating complex environmental impacts into signals that can inform consumer choices without offloading responsibility solely onto individuals (Sevigné-Itoiz et al., 2021; Sinkko et al., 2023).

3.3 Systemic resilience (Industry 5.0 calls for resilient, decentralized, and adaptable ecosystems, with strong regional networks)

Resilience is the third foundational pillar of Industry 5.0. The concept is used in EU policy documents to describe industrial ecosystems that can withstand shocks, adapt to crises, and reconfigure in ways that preserve social welfare and ecological integrity (Breque et al., 2021; ESIR, 2022). Rather than relying exclusively on highly optimized, just-in-time global supply chains, Industry 5.0 encourages diversified, decentralized, and regionally grounded production systems, supported by robust networks of SMEs, cooperatives, and social enterprises (Pilvere et al., 2015).

In bioeconomy contexts, resilience is particularly salient given exposure to climate impacts, price volatility for biomass and energy, and geopolitical disruptions. A human-centred Industry 5.0 perspective suggests that resilience is not only infrastructural and ecological but also social and institutional. Rural communities engaged in forestry, agriculture, and bio-based processing need capacities to experiment, learn, and reorganise in response to disturbances. This implies, for example, fostering diverse portfolios of bio-based activities (e.g., combining food, fibre, bio-based materials and ecosystem services), investing in local skills and entrepreneurial ecosystems, and ensuring that value from bio-based chains is retained regionally rather than being extracted by distant corporate actors (Alves et al., 2023; Lange et al., 2021).

3.4 Multi-stakeholder collaboration (Industry 5.0 emphasizes ecosystem collaboration)

Industry 5.0 is closely aligned with mission-oriented and ecosystem-based approaches to innovation policy, which argue that complex societal challenges, such as climate change and sustainability transitions, require coordinated action across public, private, and civic actors rather than isolated firm-level optimization (Directorate-General for Research and Innovation, 2024; Mazzucato, 2018). Policy documents emphasize "ecosystem collaboration" as a defining characteristic of Industry 5.0, positioning governments, regions, businesses, research organizations, and citizens as co-producers of direction, knowledge, and resources. Applied to the bioeconomy, this shift in attention focuses on regional bio-based ecosystems, where public administrations, universities, farmers, forest owners, processors, retailers, NGOs, jointly negotiate trajectories (X. Zhang et al., 2022). Governance arrangements may take the form of bioeconomy clusters, regional innovation platforms, multi-actor partnerships, or living labs. Such arrangements are particularly relevant for rural and peripheral regions, where institutional thickness, social capital, and trust networks influence whether bio-based strategies reinforce existing inequalities or open up inclusive development paths. Citizens are not passive "final users" in these ecosystems, but rather stakeholders with a voice and agency (Bălan et al., 2025). They can participate in agenda-setting (e.g., through consultations on regional bioeconomy

strategies), co-creation (e.g., community-supported agriculture, cooperative renewable energy, and bio-refinery initiatives), and monitoring (e.g., citizen science on biodiversity impacts of biomass production). This resonates strongly with Industry 5.0's insistence on democratic legitimacy and shared ownership of industrial transformations.

3.5 Digital transformation in agriculture (digitalisation challenges and opportunities)

Digitalisation is a key enabler – but also a potential source of new asymmetries – in the transition towards a human-centred bioeconomy. Research on digital agriculture and "Agriculture 4.0" has documented how sensors, remote sensing, AI-based decision support, and farm management platforms can increase efficiency, reduce inputs, and enable fine-grained environmental monitoring, while simultaneously raising concerns about data ownership, power relations, and farmers' autonomy (Klerkx et al., 2019). OECD work on the digital transformation of agriculture similarly emphasises both the opportunities for better, evidence-based agri-environmental policies and the need for governance frameworks that protect privacy, ensure interoperability, and prevent lock-in to proprietary platforms (OECD, 2019). From an Industry 5.0 perspective, digital technologies in the bioeconomy should be deployed in ways that enhance human capabilities and relational qualities rather than merely intensifying surveillance and control. In practice, this means:

- Utilizing digital traceability and product passports with transparent information on the origin, environmental, and social impacts of bio-based products enables informed choices and strengthens trust in bio-based claims (Rasheed Aboumorra & Ladu, 2024).
- Supporting farmers and forest owners with open, user-friendly tools that respect data sovereignty and are co-designed with end-users, so that digitalisation reduces administrative burdens and enhances decision-making instead of introducing new dependencies (Wang et al., 2025).
- Leveraging digital platforms to connect producers in regional markets (e.g., online marketplaces for local bio-based products, community-supported schemes), thereby shortening value chains and reinforcing regional resilience (Blanc et al., 2019; McAllister, 2025; Talwar & Holden, 2022).

Critically, Industry 5.0 reframes digitalisation not as an autonomous technological wave but as a value-laden socio-technical process that must be governed to align with human wellbeing, sustainability, and justice – a crucial consideration in bioeconomy sectors where power asymmetries between global tech providers, agri-food corporations, and small producers are pronounced (Pilvere et al., 2015).

3.6 Policy/system reform (Industry 5.0 requires adaptive governance and supportive regulatory environments)

Industry 5.0 presupposes adaptive governance and regulatory environments capable of steering industrial and bioeconomic transitions towards societal missions rather than reacting to them ex post. This perspective aligns with mission-oriented innovation policy, which suggests that states should not only correct market failures but also actively shape and create markets in ways that address grand challenges (Mazzucato, 2018). For the bioeconomy, this translates into multi-level policy architectures that:

- Provide clear, long-term signals on climate, biodiversity, and circularity objectives (e.g., climate neutrality targets, biodiversity strategies, circular economy action plans), thereby reducing uncertainty for investors in the bio-based sector.
- Align agricultural, forestry, energy, regional development, and innovation policies to avoid contradictory incentives (e.g., between biomass for energy, food security, and biodiversity).
- Introduce regulatory frameworks and standards that define what constitutes "sustainable bio-based", prevent greenwashing, and ensure that environmental and social externalities are internalized.
- Strengthen participatory and deliberative mechanisms in policy design and evaluation, so that workers, farmers, consumers, and local communities can influence the direction and pace of bioeconomic transformations (Koukios et al., 2018; Munshi & Mani, 2025; Nilsson et al., 2021).

Industry 5.0 governance also requires institutional learning and reflexivity. Instruments such as experimentation spaces, regulatory sandboxes, and ex-ante impact assessments can help policymakers test and adapt regulations in real-world settings, particularly where digitalisation and bio-based innovation interact in novel ways (Eriksson et al., 2025). The emerging Industry 5.0 Community of Practice at the EU level exemplifies efforts to develop such reflexive governance capacities by facilitating mutual learning among diverse stakeholders and showcasing concrete practices that operationalize human-centric, sustainable, and resilient industries in various regional contexts (European Commission, 2024).

These six dimensions conceptualise Industry 5.0 as a normative and institutional framework within which the bioeconomy can be developed not merely as a technological or sectoral project, but as a human-centred societal transformation. They emphasize that citizens are structurally embedded actors in this transformation – through their preferences, practices, political voice, and participation in collaborative governance – and thus provide a theoretical lens for analyzing concrete regional bioeconomy trajectories in Europe (Bălan et al., 2025; Pilvere et al., 2015).

4 Research

The empirical analysis follows the SOFIA conceptual approach (Rončević et al., 2022), combining a structured review of grey literature with expert discussions in three case regions (Slovenia, Montenegro, and Baden-Württemberg). First, we analyzed EU, national, and regional strategies, policy reports, and project documents related to the bioeconomy, rural development, and Industry 5.0 to identify key governance arrangements, actor arrays, and implementation gaps.

These insights were then triangulated with qualitative data from expert focus groups and semi-structured discussions with public authorities, research organizations, civil society actors, and rural producers, as well as insights from governance and territorial development (Fric et al., 2023). The research design and subsequent coding were structured around three main analytical categories – (a) institutions, (b) networks, and (c) cognitive frames – and fourteen coding themes. The categories and themes are summarized in Table 1, which supports an implementation- and governance-oriented analysis of rural bioeconomy transformation. Industry 5.0 is applied here as a normative evaluative lens, rather than as a framework for market formation, enabling conditions. Empirical material was coded using the SOFIA approach and organised through three analytical categories (institutions, networks, cognitive frames), which structure both the results and the cross-case comparison. Industry 5.0 principles are used as evaluative criteria to interpret empirical findings across the three analytical categories. Institutional arrangements, network structures, and cognitive frames are evaluated in terms of their contributions to or obstructions of human-centricity, sustainability, resilience, and inclusive governance.

Table 1: Codebook divided by categories and themes

Theme	Theme description
Category: Institutions	
Institutional engagement & strategic orientation	References to national/regional strategies, institutional mandates, or organisational roles in rural bioeconomy or innovation
Bottom-up vs Top-down governance dynamics	Tensions, complementarities, or failures in cooperation between central authorities and local stakeholders.
Funding availability, accessibility and limitations	Issues concerning availability of funds, administrative burdens, match funding, sustainability after funding, scale-up problems
Legislation, regulation and policy coherence	Misalignment of regulations, inconsistent legal interpretation, regulatory barriers to circular practices
Digitalisation and e-government barriers	Digital literacy, availability of digital public services, administrative digital tools
Governance capacities and administrative barriers	Bureaucratic inefficiencies, inconsistent local procedures, lack of coordination, weak advisory services
Category: Networks	
Local initiatives, community energy and embedded knowledge	Locally anchored practices, informal organisations, grassroots entrepreneurship, rural knowledge
Market integration and scale-up challenges	Difficulties transitioning from pilot projects to market, lack of cooperatives, inadequate economies of scale
Stakeholder collaboration & networks	Evidence of cooperation between universities, research institutions, civil society, farmers, businesses, clusters
Power asymmetries and unequal Participation	Unequal influence across actors, institutional dominance, marginalised groups
Innovation ecosystems and technological potential	Availability and use of technologies, digital tools, AI, new value-chain methods, robotisation
Category: Cognitive frames	
Civil society roles, capacities and limitations	Contributions of NGOs, their advocacy role, community connections, political tensions, and structural barriers
Social and generational factors	Demographic change, youth migration, attitudes of older versus younger farmers, cultural norms
Success stories and enabling factors	Concrete examples of successful bio-based initiatives and what enabled them
Long-term sustainability and future directions	Measures needed for durable bioeconomy transitions

Source: own work, 2025.

5 Results

Findings are presented in line with the analytical framework outlined in Table 1, which is structured around three overarching categories and their associated coding themes. The section emphasises cross-case patterns as well as region-specific distinctions across Slovenia, Montenegro, and Baden-Württemberg. Responses were coded based on the identified themes. The results are as follows:

5.1 Institutions

Institutional Engagement and Strategic Orientation

Across Slovenia, Montenegro, and Baden-Württemberg, institutions exhibit different levels of strategic maturity in rural bioeconomy development. Slovenian research organisations demonstrate a long-term commitment, having produced concrete innovations, such as bio-based packaging from tomato residues. Baden-Württemberg benefits from coherent regional planning supported by federal instruments. Montenegro, by contrast, appears to employ high-quality strategies that often fail to translate into effective implementation. This gap between aspiration and delivery reveals a structural weakness where political ambition and administrative capacity remain unaligned.

Bottom-Up vs Top-Down Governance Dynamics

Local initiatives in all regions demonstrate motivation and contextual expertise, yet central authorities often fail to recognise or support this potential. In Montenegro, bottom-up activity is widespread but undervalued. Slovenia's bottom-up processes are visible, but structurally limited by the absence of a regional structural organisation. Meanwhile, Baden-Württemberg benefits from more structured interactions; however, challenges emerge when initiatives extend beyond regional boundaries. The evidence for all regions in question suggests that top-down strategies remain overly bureaucratic and insufficiently adaptive to local realities.

Funding Availability, Accessibility, and Limitations

While focus group participants acknowledge that funding channels exist, these channels often remain inaccessible to rural actors due to the complexity of administrative processes. EU programmes are perceived as too bureaucratic and impose significant reporting burdens, leaving smaller organisations with limited human resources. Early-phase project funding is attainable; however, financing for scale-up is scarce, and private investors often show reluctance to enter uncertain markets. Slovenian and German actors are exploring alternative financial models, reflecting growing recognition that reliance on competitive EU calls is insufficient.

Legislation, Regulation and Policy Coherence

Regulatory frameworks often lag behind the principles of circularity. This was observed in cases such as waste classification rules, where certain rules, particularly those applicable to Slovenia, hinder the transformation of waste streams into secondary raw materials. Such a situation discourages circular practices. In Montenegro, strategies and laws exist, but they are inconsistently interpreted and poorly coordinated across institutions. Exhibited legal and policy incoherence creates uncertainty and limits the scope for experimentation required in the bioeconomy.

Digitalisation and E-Government Barriers

Digitalisation is viewed as essential but remains unevenly developed. Montenegro, in particular, faces challenges with limited digital services, weak institutional coordination, and low citizen digital literacy. These barriers hinder access to funding, administrative processes, and the adoption of innovative solutions. Systematic investment in digital education and interoperable public services is necessary in the context of Montenegro.

Governance Capacities and Administrative Barriers

Administrative inefficiency consistently emerges as a significant obstacle in all the countries in question. Montenegro faces acute challenges: inconsistent procedures, weak advisory services, and a lack of basic producer data at the municipal level. Even in Slovenia and Baden-Württemberg, complex administrative requirements limit the participation of stakeholders across value chains in the bioeconomy. These barriers disproportionately affect small producers, reinforcing existing inequalities and hindering the uptake of innovation.

These institutional barriers directly undermine the human-centric and resilience-oriented objectives of Industry 5.0. From the perspective of the research question, these findings suggest that institutional enablers and barriers at multiple governance levels significantly influence whether rural bioeconomy strategies can transition from formal alignment with Industry 5.0 principles to their practical implementation.

5.2 Networks

Local Initiatives, Community Energy, and Embedded Knowledge

Grassroots initiatives showcase the potential of community-driven innovation, particularly emphasised in Montenegro. It is in Montenegro that examples from women-led wool valorisation groups and local composting projects illustrate practical and

socially embedded solutions. Such initiatives, however, receive limited recognition from central authorities, reflecting a persistent undervaluation of local knowledge and bottom-up leadership.

Market Integration and Scale-Up Challenges

Transitioning from pilot activities to market-ready solutions remains difficult across regions. Many rural actors lack the financial and organisational capacity to scale up, and cooperative structures are often underdeveloped. Perceptions that bio-based products are inherently more costly discourage broader market adoption. These structural limitations hinder the evolution of pilot projects into enduring economic activities.

Stakeholder Collaboration and Networks

Cooperation among research institutions, civil society, farmers, and businesses forms the backbone of many successful initiatives. This holds true for all three countries. Examples include Slovenian research–industry partnerships and Montenegro's NGO-led rural engagement. Networks, however, are often dependent on project funding and tend to dissolve once the financial cycle ends. Sustained collaboration requires more institutionalised structures that go beyond temporary project formats.

Power Asymmetries and Unequal Participation

Larger institutions and well-resourced actors remain better positioned to shape bioeconomy agendas, while smaller producers and local communities struggle to access funding or influence policy. Potential political tensions between NGOs and state actors can further complicate the process of inclusive governance. These asymmetries risk undermining efforts toward socially equitable bioeconomy transitions.

Innovation Ecosystems and Technological Potential

Technological tools, such as digital material stream analytics, wastewater reuse technologies, and early-stage agricultural automation, offer promising opportunities for improvement. Slovenia and Baden-Württemberg appear better positioned to adopt these innovations, while Montenegro struggles with digital literacy and limited infrastructure. Technology alone cannot compensate for institutional weaknesses, but it remains an important enabler when embedded within supportive governance systems.

The project-based nature of networks limits the development of resilient and inclusive Industry 5.0-aligned ecosystems. This demonstrates that, within a multi-level stakeholder governance context, network stability and institutionalization function as key enablers for

Industry 5.0 goals, while project dependence constitutes a structural barrier to resilience and long-term transformation.

5.3 Cognitive frames

Civil Society Roles, Capacities and Limitations

Civil society organisations play a central role in supporting rural actors, particularly in Montenegro, where NGOs enjoy higher levels of trust among citizens than state institutions. They contribute to capacity-building, advocacy, and direct mentorship. Yet political scepticism, limited financial stability, and constrained access to policymaking processes restrict their broader systemic influence. In Germany, resource limitations prevent many NGOs from participating meaningfully in strategic debates.

Social and Generational Factors

Demographic change and generational divides shape rural innovation trajectories. Older rural residents often lack digital competencies, while younger people may lack motivation to remain in agriculture or rural areas. Participants argue that broader cultural change is essential to avoid deepening social and economic decline. Within this context, initiatives such as campaigns to valorise rural entrepreneurship were outlined.

Success Stories and Enabling Factors

Examples such as Slovenia's tomato-stem packaging and Montenegro's composting initiatives demonstrate that progress is possible when local demand, cross-sector collaboration, and appropriate funding align. Clusters and regional cooperation can enhance the likelihood of success, but such cases remain exceptions rather than systemic patterns.

Long-Term Sustainability and Future Directions

Long-term progress was noted to require stable financial frameworks, market development, legislative reform, and stronger local governance capacities. Participants emphasise that project-based interventions are insufficient. Without systemic changes in addressing markets, governance, and cultural barriers, the bioeconomy risks remaining fragmented and failing to deliver transformative outcomes. These cognitive frames shape how stakeholders perceive legitimacy, risk, and opportunity, thereby mediating the effectiveness of governance arrangements and influencing whether Industry 5.0 principles are internalised or remain abstract policy narratives.

The results suggest that rural circular bioeconomy development does not fail at a single point but at the intersection of institutions, networks, and cognitive frames: where institutions can implement strategies (not merely produce them), where networks remain stable beyond project cycles, and where collaboration and trust dominate the prevailing mindset, tangible innovations and steps toward market uptake emerge. Conversely, in contexts marked by a persistent strategy–implementation gap, weak digital and administrative capacity, and uneven power distribution among actors, innovation tends to stall at the pilot level. Local initiatives remain largely supported through informal arrangements, and the system remains fragmented. In comparative terms, Baden-Württemberg exhibits more coherent institutional support and vertical coordination. Slovenia demonstrates relatively strong research-to-innovation examples but faces constraints in coordination and scaling. Montenegro exhibits high bottom-up energy, yet it encounters the strongest barriers in implementation capacity, digitalization, and the formal integration of civil society into decision-making processes.

6 Discussion

This discussion directly addresses the research question of how multi-level stakeholder governance enablers and barriers shape the implementation of rural bioeconomy in relation to Industry 5.0 normative guidelines. The findings confirm that the implementation of the rural bioeconomy in line with Industry 5.0 is primarily a multi-level stakeholder governance problem rather than a technological one. In stakeholder governance, value creation depends on governance arrangements that mitigate collective action problems and sustain cooperation among interdependent actors through perceived fairness, voice, and credible commitments (Freeman, 1984; Bridoux & Stoelhorst, 2022). Industry 5.0 adds a normative benchmark: transitions should be human-centric, sustainable, resilient, and democratically legitimate (Breque et al., 2021). Our cases demonstrate that the gap between ambition and delivery arises when these normative expectations intersect with the realities of fragmented institutions, unstable coordination, and contested legitimacy—classic failure modes of multi-level governance in territorially embedded transitions.

Institutional barriers in the cases can be explained as coordination failures across levels and sectors. Multi-level governance requires the alignment of policy objectives, rules, and instruments across ministries, agencies, regions, and municipalities—especially when policy issues encompass climate change, biodiversity, agriculture, waste/circularity, innovation, and regional development (European Commission, 2018b); Lange et al., 2021). Where alignment is weak, actors face contradictory signals and inconsistent regulatory interpretation. In governance theory terms, this increases transaction costs (time, compliance, uncertainty), which disproportionately burdens small rural actors and undermines inclusive stakeholder participation—directly conflicting with Industry 5.0's human-centricity. From an Industry 5.0 perspective, such institutional

failures undermine human-centricity and democratic legitimacy by systematically excluding less-resourced rural stakeholders from meaningful participation.

A second institutional barrier concerns implementation capacity. Mission-oriented strategies can create compelling narratives, but without administrative capacity and enabling instruments, they remain "strategy without delivery" (Mazzucato, 2018). The cases illustrate this mechanism clearly: even where strategies are comparatively mature, administrative burdens, regulatory lag, and insufficient scale-up instruments prevent pilots from becoming durable territorial pathways. Montenegro exemplifies this mechanism in a more pronounced form: strategic ambition is evident, yet execution is constrained by limited administrative capabilities and weak institutional interoperability. Theoretically, this is not a "Montenegro problem"; it is the predictable outcome when institutional design over-emphasises planning and under-invests in delivery capacity at the subnational level.

From a stakeholder governance perspective, the most relevant institutional enablers are those that reduce transaction costs and make participation feasible for less-resourced stakeholders, including coherent regulatory interpretation, simplified procedures, advisory capacity, interoperable e-government, and funding designs that reward long-term collaboration and scale-up rather than merely compliant reporting. This reframes "administrative simplification" as a fairness mechanism, reducing structural exclusion and enhancing the perceived legitimacy of the transition.

The analysis of networks suggests that many promising rural bioeconomy initiatives are effectively "projectified". Cooperation between research institutions, civil society organisations, farmers, and businesses often depends on time-limited project funding, and networks tend to weaken once funding cycles come to an end. Even in Baden-Württemberg, where regional planning and cluster structures are comparatively strong, respondents highlight difficulties in maintaining collaboration beyond specific initiatives or administrative boundaries. In Montenegro, vibrant grassroots activity – including women-led wool initiatives and composting projects – remains weakly connected to formal innovation systems and lacks stable institutional support. This stands in tension with Industry 5.0's emphasis on ecosystem collaboration and mission-oriented, multi-actor partnerships (Breque et al., 2021; Directorate-General for Research and Innovation, 2024) and with stakeholder governance approaches that conceive firms and territories as nexuses of formal and informal contracts linking diverse stakeholders (Jones, 1995; Freeman & Phillips, 2002). The results, therefore, add empirical weight to concerns that, without institutionalised and durable network structures, stakeholder rhetoric may obscure rather than resolve underlying coordination problems. The network findings are best interpreted through theories of network governance and stakeholder coordination. Stakeholder governance assumes that cooperation can be sustained when actors perceive a fair distribution of value and can rely on stable relationships (Bridoux & Stoelhorst,

2022). In practice, many rural bioeconomy initiatives are "projectified": cooperation is assembled around time-limited funding and dissolves when projects end. This produces weak credible commitment and limited accumulation of relational capital—so learning, trust, and coordination costs reset every cycle. In Industry 5.0 terms, this undermines resilience: ecosystems cannot become robust if they are structurally temporary.

This is why intermediaries matter, both theoretically and practically. Durable intermediaries (cluster organisations, cooperatives, regional coordinators, boundary spanners) function as governance infrastructure: they lower coordination costs, stabilise cooperation beyond programme cycles, and help resolve conflicts across administrative boundaries. Without them, "stakeholder governance" becomes rhetorical—an invitation to collaborate without institutional conditions that make collaboration sustainable. This so-called project-based logic stands in clear tension with Industry 5.0's emphasis on resilience, which presupposes continuity, learning, and durable stakeholder relationships rather than episodic cooperation (Bhiri, 2025; Lampel, 2011).

Power asymmetries reinforce these network failures. When better-resourced actors dominate agenda-setting and access to funding, stakeholder governance fails its own premise of fairness: those who must implement change locally become peripheral. This also reduces effectiveness because territorially misaligned solutions emerge when implementers lack a voice. A direct theoretical implication is that inclusive partnerships are not only normative but also efficiency-enhancing, as they improve problem-fit and implementation feasibility.

Cognitive frames further mediate these institutional and network dynamics. Across regions, civil society organisations are recognised as crucial intermediaries, particularly in Montenegro, where NGOs enjoy relatively high levels of trust and play a central role in capacity-building and mentoring. Yet they operate under conditions of financial precarity, political scepticism, and limited access to formal decision-making arenas – an empirical illustration of theoretical arguments about stakeholders outside the firm who nevertheless invest in firm- or system-specific assets that are vital for value creation (Brandenburger & Stuart, 1996; Bridoux & Stoelhorst, 2022). Demographic change and generational divides amplify these tensions: older rural residents often lack digital competencies, while younger people are reluctant to remain in agriculture or rural areas, reflecting wider cultural narratives that undervalue rural entrepreneurship and bio-based innovation (Klerkx et al., 2019; Gangaliuc, 2022). These findings underscore that human-centered Industry 5.0 futures cannot be built solely on technological upgrading; they require shifts in societal attitudes, recognition of local knowledge, and explicit efforts to mitigate social fragmentation.

The three categories – institutions, networks, and cognitive frames – thus jointly reveal a tension between the normative promises of stakeholder governance and Industry 5.0 and

the realities of rural bioeconomy development. Theoretically, stakeholder governance assumes that value creation and value capture can be aligned through mechanisms that ensure perceived fairness and sustain cooperation (Bridoux & Stoelhorst, 2022; Zollo et al., 2018). In practice, our cases reveal institutions that remain rigid, fragmented, and risk-averse; networks that are episodic and overly reliant on project logic; and cognitive frames that continue to privilege expert and centralized perspectives over local, experiential knowledge. Against this backdrop, the role of citizens emerges as both constrained and potentially transformative. On the one hand, their capacity to act as co-producers of bioeconomy trajectories is limited by information asymmetries, uneven access to digital tools, and the absence of stable markets for many bio-based products (Gaffey et al., 2021). On the other hand, the evidence around short supply chains, regional quality schemes, and local brands aligns with research on circular and regional bioeconomy pathways (Korhonen et al., 2018; Uršič et al., 2024; Buruleanu et al., 2025). These asymmetries contradict the Industry 5.0 assumption that industrial and bioeconomic transitions should be co-shaped by those most affected by their outcomes.

Taken together, the chapter's comparative perspective across Slovenia, Montenegro, and Baden-Württemberg supports the view that aligning rural bioeconomy strategies with Industry 5.0 is fundamentally a governance challenge, not a technological one. Industry 5.0 has been conceptualised as a normative and institutional framework that links competitiveness to sustainability, circularity, and human-centricity (Breque et al., 2021; Alves et al., 2023), while the bioeconomy has been framed as a systemic transition towards renewable, circular use of biological resources (European Commission, 2018b); Wreford et al., 2019). Our findings suggest that these agendas can only converge if multi-level stakeholder governance is strengthened along three dimensions: (i) reducing administrative and regulatory barriers that disproportionately affect small producers; (ii) moving beyond project-based collaboration towards more institutionalised, long-term network structures; and (iii) addressing social and generational divides through targeted support for skills, civic engagement, and rural entrepreneurship. These are not marginal "accompanying measures", but preconditions for realising a human-centred, sustainable and resilient bioeconomy, consistent with recent calls for more reflexive, justice-oriented understandings of circular and bio-based transitions (Korhonen et al., 2018; Uršič et al., 2024).

At the same time, the study has limitations that delimit the scope of its conclusions. The empirical base is limited to three European regions and relies on qualitative expert discussions combined with grey literature, which restricts representativeness and fails to capture the full diversity of rural bioeconomy trajectories within or beyond the EU. The coding framework, while systematic, reflects specific theoretical choices – stakeholder governance, Industry 5.0, and bioeconomy – and may underplay other relevant dimensions such as land-use conflicts or global value-chain dynamics. Nonetheless, the cross-case patterns identified here highlight governance bottlenecks that are likely to be

relevant in other rural contexts and provide a conceptual and empirical basis for more fine-grained, future research on how consumers and citizens can be meaningfully integrated into bio-based, Industry 5.0-aligned development pathways. Thus, the empirical evidence confirms that Industry 5.0 can only function as a meaningful orientation for the rural bioeconomy if stakeholder governance arrangements are capable of translating normative ambitions into territorially embedded practices.

7 Conclusions

There are numerous chances to further sustainability objectives at the nexus of Industry 5.0 and rural bioeconomy development. However, comprehending the major enablers and barriers that influence governance frameworks is essential for successful implementation.

The objective of this paper is to highlight that the implementation of the rural bioeconomy in line with Industry 5.0 primarily hinges on the quality of multilevel stakeholder governance—rather than technology—and that without institutional, network, and cognitive conditions, Industry 5.0 remains a normative ambition without real-world implementation.

The chapter identifies several governance enablers that align closely with Industry 5.0 principles of human-centricity, collaboration, resilience, and sustainability. These enablers include institutions capable of implementing strategies rather than merely designing them, stable stakeholder networks that persist beyond short-term project cycles, trust-based collaboration and shared cognitive frames, and the emergence of tangible innovations with pathways toward market uptake.

At the same time, the analysis clearly outlines governance barriers that hinder effective implementation. These include persistent strategy–implementation gaps at the institutional and policy levels, weak digital and administrative capacity, uneven power distribution among stakeholders, and fragmented systems that rely heavily on informal arrangements. Where such barriers dominate, innovation tends to remain confined to pilot projects, coordination across governance levels is constrained, and the rural bioeconomy struggles to scale in a systemic and durable manner.

The findings indicate that the development of rural circular bioeconomies does not fail at a single spatial or organizational level, but rather at the interface between institutions, networks, and dominant cognitive frames. Meaningful innovation and progress toward market uptake emerge when institutions possess the capacity to implement strategies rather than merely formulate them, when cooperation networks remain stable beyond short-term project cycles, and when trust-based collaboration prevails among relevant actors.

In contrast, innovation frequently stagnates at the pilot stage in contexts characterized by persistent gaps between strategic planning and implementation, limited digital and administrative capacity, and asymmetrical power relations among stakeholders. In these situations, local initiatives are often supported by informal agreements rather than formal support systems, and the governance structure remains disjointed.

In conclusion, the findings imply that inclusive stakeholder governance improves efficiency and is normatively desirable. It increases implementation feasibility and improves the alignment between policy instruments and context-specific challenges, consequently strengthening long-term systemic resilience.

Advancing the rural bioeconomy within an Industry 5.0 framework, therefore, depends less on technological readiness and more on the redesign of governance systems that can sustain collaboration, embed trust, and translate strategic ambition into durable territorial transformation.

An organized approach to governance can mitigate the detrimental impacts of conflicting interests that often impede progress within industrial sectors (Bingham et al., 2005). By pursuing collaborative initiatives while reinforcing regulatory frameworks, the EU can ensure that the transition to Industry 5.0 addresses not only technological advancements but also the socio-economic dimensions of industrial development. The analysis reinforces the notion that effective rural circular bioeconomy development requires governance frameworks that can sustain collaboration, trust, and strategic alignment. Strategies must aim to bridge implementation gaps and empower local stakeholders, making inclusive governance not only desirable but essential for ensuring the alignment of policy instruments with local challenges.

Acknowledgment:

The research was supported by the Slovenian Research and Innovation Agency (ARIS) through the annual work program of Rudolfovo – Science and Technology Centre, and also supported by Rudolfovo – Science and Technology Centre and the Slovenian Research Agency Program P5-0445. The authors acknowledge that the data were collected within the scope of the Interreg RuBIO to boost innovation and competitiveness of entrepreneurs under the Programme 2021 - 2027, co-funded by the Interreg VI-B Danube program of the European Union [grant number DRP0400980].

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Part IV

European Industry 5.0 for Community Well-being

Implementing Human-Centricity: Exploring the Foundations of Psychological Safety

TJAŠA STEPIŠNIK PERDIH & JANA KRIVEC [1]

Abstract While research traditionally frames psychological safety as a group-level, team-based construct, its individual-level understanding remains less explored. This study investigates the subjective meaning of psychological safety through a thematic analysis of qualitative responses from 111 part-time students in Slovenia. Findings revealed three primary themes. The most dominant theme was Interpersonal & Relational (relationships, emotional support and acceptance, values of interpersonal relationships). This was followed by Material Security & Situational Stability (financial and material security, health, stability and peace) and, to a lesser extent, Internal Personal Factors (self-confidence, autonomy, emotional stability). These results indicate that an individual's perception of psychological safety is a broad, socially embedded construct that extends beyond organizational boundaries, linking to one's local community and personal life. By recognizing this interconnected sense of safety, organizations and societies can better align with the holistic, human-centric principles that define the fifth industrial revolution.

Keywords: • sense of safety • psychological safety • subjective safety • Industry 5.0

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https://doi.org/10.4335/2026.2.9 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

Industry 4.0, often regarded as the fourth industrial revolution, was characterized by its reliance on advanced technologies such as cyber-physical systems, the Internet of Things (IoT), and artificial intelligence to create data-driven, interconnected, and highly efficient smart organizations. This paradigm primarily focused on automation, productivity, and optimization, placing technology at the centre of industrial processes (Breque et al., 2021; Gamberini & Pluchino, 2024; Majerník et al., 2022; Romero et al., 2016).As such, it has often ignored original principles of social fairness and sustainability (Breque et al., 2021).

Industry 5.0 maintains the technological foundations of its predecessor but reframes them through a human-centric lens. It represents a conceptual expansion and should not be understood as a chronological continuation of, or an alternative to, the existing Industry 4.0 paradigm. Instead, it re-contextualizes the technological advancements of Industry 4.0 and is the result of a forward-looking exercise (Breque et al., 2021).

This new concept provides a different focus, shifting away from a technology-first, efficiency-driven model toward one that is fundamentally sustainable, resilient, and human-centric (Breque et al., 2021; Pathak et al., 2023; Trstenjak et al., 2025). According to the definition by Breque et al. (2021, p.14): 'Industry 5.0 recognises the power of industry to achieve societal goals beyond jobs and growth to become a resilient provider of prosperity, by making production respect the boundaries of our planet and placing the wellbeing of the industry worker at the centre of the production process'.

A central aspect of this evolution lies in redefining the role of the human within industrial systems. In the Industry 4.0 paradigm, the worker, often labelled the Operator 4.0, was conceived as a technologically augmented component within a cyber-physical system. It was often framed as a 'resource', a 'component to be optimized', or a 'human-in-the-loop' managing an otherwise autonomous process. As such, the Operator 4.0 is a 'smart and skilled operator' who collaborates with automation and uses technologies such as augmented reality, cobots, and wearables to enhance performance and safety (Romero et al., 2016). The primary goals were productivity and optimization, often at the expense of human agency and well-being (Majerník et al., 2022). As we can see, in this model, the human's value was primarily instrumental, defined by their ability to complement machine efficiency.

Conversely, a human-centric approach in industry puts core human needs and interests at the heart of the production process (Breque et al., 2021; Grabowska et al., 2022; Zafar et al., 2024). The central question changes from asking what we can do with new technology, to asking what the technology can do for us (Breque et al., 2021). Technology is intended to serve people and adapt production processes to worker needs, ensuring that its use does not impinge on workers' fundamental rights, such as the right to privacy,

autonomy and human dignity (Breque et al., 2021; Pathak et al., 2023). The goal is to promote inclusive human-technology collaboration and create a fair social contract where technology enhances humanity and not replaces it (Zafar et al., 2024).

In this model, the worker is considered an investment or asset rather than a cost, enabling parallel development for both the organization and its employees. Such a perspective signifies an employer's strategic interest in investing in the skills, capabilities, and well-being of their employees to attain organizational goals (Breque et al., 2021; Pathak et al., 2023; Zafar et al., 2024). Gamberini & Pluchino (2024) mention a strong link between employee well-being and 'healthy organizations'. Industry 5.0 is characterized by a higher appreciation for human capital, and the entire human-centric framework rests on the prerequisite that technology serves people, not the inverse (Breque et al., 2021).

This distinction in human roles is captured in the evolution from Operator 4.0 to Operator 5.0, or, alternatively, Resilient Operator 5.0, because the evolution to Industry 5.0 is marked by the introduction of resilience. The Operator 5.0 is defined as 'a smart and skilled operator that uses human creativity, ingenuity, and innovation empowered by information and technology as a way of overcoming obstacles in the path to create new, frugal solutions for guaranteeing manufacturing operations sustainable continuity and workforce wellbeing in light of difficult and/or unexpected conditions' (Romero & Stahre, 2021, p. 1090). This concept necessitates a comprehensive approach that prioritizes the human element alongside technology and concentrates on two areas: self-resilience concerning the operator's biological, physical, cognitive, and psychological health, and system-resilience, which ensures the shared adaptability of human–machine systems to maintain optimal performance (Romero & Stahre, 2021).

This vision places the well-being of the worker and the value of unique human contributions, such as critical thinking, creativity, and complex problem-solving, back at the centre of the industrial process. Humans are seen as active participants in technological advancement. Dynamic collaboration between humans and intelligent machines will enable them to perform novel or unfamiliar tasks safely and effectively. This integration of human ingenuity and technological capability is seen as the foundation of Industry 5.0 (Zafar et al., 2024).

In order for this to happen, workers' autonomy, dignity, and mental health must be protected. The 'always-online' and 'always-available' working culture associated with digitization creates new risks, including burnout and cognitive overload; however, digital technologies could also be utilized to support workers in controlling and managing the effects of this new environment on their mental health and well-being (Breque et al., 2021).

Trstenjak et al.'s (2025) systematic review confirms that human-centricity, sustainability, and resilience are the core pillars of the Industry 5.0 concept and that this perspective emphasizes the development of socio-technical systems designed to enhance human health, well-being and safety, but what does safety mean in this new context?

1.1 The concept of Safety

Safety is considered a basic human need and a fundamental human right. It is commonly defined as 'the state of being protected from danger or harm' (*SAFETY | English Meaning - Cambridge Dictionary*, n.d.)or as 'the condition of being safe from undergoing or causing hurt, injury, or loss' (*SAFETY Definition & Meaning - Merriam-Webster*, n.d.). Within injury prevention research, safety is conceptualized as a state of 'adequate control over physical, material, or moral threats, contributing to a perception of protection from harm' (Andersson & Svanström, as cited in Nilsen et al., 2004, p. 71). It is often defined and measured more by its absence than its presence (Nilsen et al., 2004).

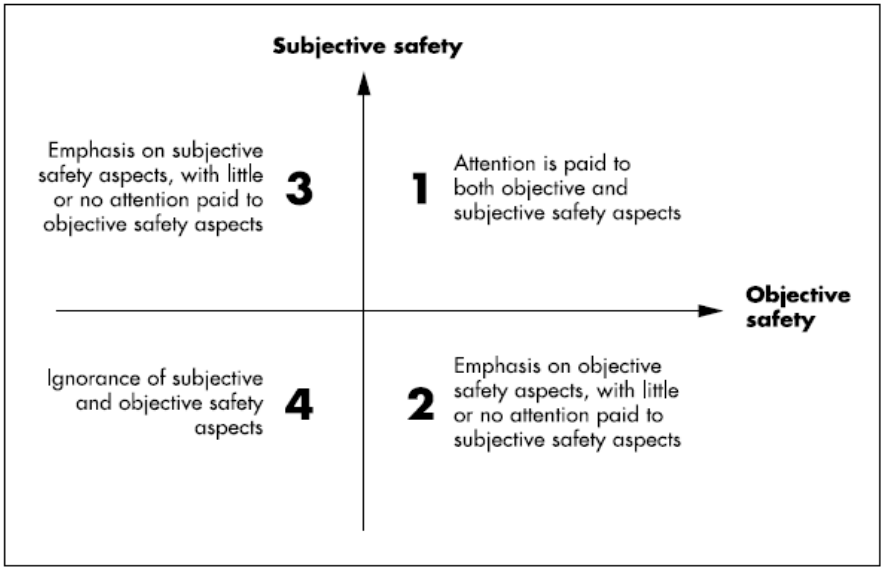
Recognizing the need for a comprehensive and unified definition, the World Health Organization (WHO) initiated an international effort to establish a consensus on the conceptual and operational aspects of safety. Safety has since been defined as 'a state in which hazards and conditions leading to physical, psychological or material harm are controlled in order to preserve the health and well-being of individuals and the community. It is an essential resource for everyday life, needed by individuals and communities to realise their aspirations' (Maurice et al., 1998, p. 6). Safety is thus a comprehensive concept that actively safeguards physical, psychological, and material well-being, encompassing far more than the simple absence of injury. Maurice et al. (1998) argue against a narrow, traditional focus on 'objective safety' focused on measurable risk reduction. They stress the need to incorporate 'subjective safety', the individual's or community's perception and feelings of safety, as these perceptions have powerful implications for mental health, behaviour, and social participation. The WHO framework thus distinguishes between two primary dimensions (Maurice et al., 1998):

1 Objective (External) Safety: The verifiable, data-based level of safety determined by environmental and behavioural measures, expert criteria, and verifiable data such as accident statistics or hazard assessments.
2 Subjective (Internal) Safety: The personal or collective perceived 'feeling' or 'sense of safety'. This feeling is not always rational and can be influenced by factors like media, personal experiences, or social cues.

These dimensions influence each other and interact dynamically. They can also diverge, creating mismatches between 'real' and 'felt' safety. To conceptualize these relationships, Maurice et al., (1998) propose a two-dimensional matrix which Nilsen et al., (2004) presented in four distinct quadrants (see Figure 1):

- Q1- **High Objective Safety + High Subjective Safety:** The ideal 'Safe Zone' in which both measurable safety and perceived safety are high. Individuals are objectively protected from harm and feel safe within their environment.
- Q2 - **High Objective Safety + Low Subjective Safety**: The 'Anxious/Fearful Zone', represents a psychologically significant state where, despite low risk, individuals or communities feel unsafe, for example high fear of crime in statistically safe neighbourhoods. This dissonance can lead to stress, social withdrawal, and reduced physical activity, negatively impacting health.
- Q3 **– Low Objective Safety + High Subjective Safety**: The 'Ignorant/Complacent Zone', a condition where people feel safe despite genuine hazards. This misperception can encourage risk-taking behaviours and disregard for safety measures, for example ignoring health warnings.
- Q4 **– Low Objective Safety + Low Subjective Safety:** The 'Dangerous Zone' is an unambiguous crisis state, characterized by actual and perceived danger. Individuals are both exposed to and aware of high risk, necessitating urgent intervention (Maurice et al., 1998; Nilsen et al., 2004).

Figure 1: Approaches to defining and operationalising safety concepts (Nilsen et al., 2004).



This framework underscores that safety promotion must address both objective protection from harm and subjective feelings of security. Enhancing the sense of safety is as crucial

as mitigating actual risks, as it empowers individuals and communities to live fully and confidently within their environments (Nilsen et al., 2004). The evolution from Industry 4.0's Operator 4.0 to Industry 5.0's Operator 5.0 mirrors this conceptual shift in the understanding of safety: it moves from a narrow focus on objective, measurable features toward a holistic, human-centric perspective that also values psychological well-being.

1.2 Psychological safety

The concept of psychological safety emerged from the work of Schein and Bennis (1965, cited in Edmondson & Lei, 2014), who identified it as a critical condition for effective organizational change. They argued that psychological safety enables individuals to overcome defensiveness and learning anxiety when confronted with information that challenges existing assumptions, allowing them to prioritize collective objectives over self-protection.

Following a period of relative neglect, the construct reemerged in the 1990s with Kahn's qualitative research. Kahn (1990) conceptually linked psychological safety to personal engagement, proposing that it determines individuals' willingness to express themselves physically, cognitively, and emotionally in their roles rather than withdrawing to protect their sense of self. He further argued that such safety is fostered by interpersonal relationships characterized by mutual trust and respect.

Since then contemporary research on psychological safety has expanded significantly, driven by the increased importance of organizational learning and innovation. Edmondson & Lei (2014) organized this vast body of work into three levels of analysis:

1 Individual-Level Contexts
This research stream examines an individual's personal experience of psychological safety and its impact on their work outcomes. Studies differentiate between two types of outcomes:
- **In-Role Behaviour** where studies focused on employee performance in expected behaviours for their roles, such as individual's engagement in their work. For example, research has shown that psychological safety fosters feelings of vitality, which in turn predict greater involvement in creative work (Kark & Carmeli, 2009). It also motivates knowledge sharing among coworkers (Siemsen et al., 2009).
- **Speaking Up and Voice (Extra-Role Behaviour)**: A growing body of work examines psychological safety's relationship to extra-role behaviours such as speaking up or 'voice'. This is an 'upward-directed, promotive verbal communication' (Dyne & LePine, 1998; Premeaux Fontenot & Bedeian, 2003). This behaviour is vital for organizational learning but is often inhibited by interpersonal risk. Studies consistently find that psychological safety is a key

mediator through which leadership fosters voice. For instance, it mediates the relationship between change-oriented (Detert & Burris, 2007) and ethical leadership (Walumbwa & Schaubroeck, 2009) and subsequent employee voice. Furthermore, research has distinguished between promotive voice (expressing improvements that could benefit the organisation) and prohibitive voice (expressing concerns about what might harm the organisation), finding that psychological safety is a particularly strong predictor of the latter, riskier behaviour (Liang et al., 2012).

2 Organizational-Level Contexts

At this level, psychological safety is conceptualized as an organizational climate, measured as an average of employee perceptions across the firm.

- **Organizational Performance**: Research in this context links psychological safety to firm-level success. For example, studies of high-technology firms found that commitment-based HR practices foster a 'social climate of trust' (a highly similar construct), which predicts knowledge exchange and, ultimately, improved firm performance (Collins & Smith, 2006). A study in German companies found that a climate for psychological safety was positively correlated with firm performance, especially by supporting process innovations (Baer & Frese, 2003).
- **Organizational Learning**: A key application at this level involves 'learning from failure'. Studies show that high-quality relationships and social capital within an organization build psychological safety, which in turn enabled failure-based learning (Carmeli & Gittell, 2009).

3 Group-Level Contexts

This is identified as the largest and most active research stream and was initiated by Edmondson's (1999) foundational work. This research supported the conclusion that psychological safety is essentially a group-level phenomenon, as for it to be a group-level construct, it must characterize the team rather than individual members, and team members must hold similar perceptions of it. Edmondson confirmed this by demonstrating that psychological safety did indeed vary significantly between different groups within the same organization.

In this context, psychological safety has been studied mainly in three roles:

- **As an Antecedent**: Psychological safety is shown to be a direct predictor of team outcomes. Choo et al. (2004) showed that a psychologically safe environment fosters divergent thinking, creativity, and risk-taking. It also motivates engagement in both exploratory and exploitative learning, which in turn promotes team performance.
- **As a Mediator**: This is a common conceptualization, where psychological safety is the mechanism connecting team inputs (structure, leadership, team characteristics)

to team outputs (learning, innovation, performance). For example, inclusive leadership predicted higher team performance through the mechanism of first building psychological safety (Hirak et al., 2012).

- **As a Moderator**: More recent research explores psychological safety as an enabling condition that alters the relationship between other variables. In this context, psychological safety mitigates the negative effects of team challenges.Gibson & Gibbs (2006), for instance, found that in geographically dispersed teams, a psychologically safe communication climate was found to counteract the negative consequences of virtuality (e.g., national diversity, electronic dependence) on team innovation.

Psychological safety has consistently been shown to play a role in enabling performance, particularly when work is characterized by uncertainty and requires creativity or collaboration, and organizational learning as learning behaviours can be limited by interpersonal risks, such as the fear of appearing incompetent. A climate of psychological safety mitigates these risks, making people more likely to offer ideas, admit mistakes, ask for help, or provide feedback. This environment also enables 'voice' or speaking up, allowing employees to challenge the status quo or identify problems which is often perceived as too risky without psychological safety (Edmondson & Lei, 2014).

However, safety alone is not enough. When certain conditions supporting teamwork, such as task interdependence, are missing, psychological safety may not lead to team learning and performance. Its impact on knowledge sharing was also found to be lower when individuals had more confidence in their knowledge. Its effect on learning is also stronger when the work itself is more uncertain (Edmondson & Lei, 2014; Siemsen et al., 2009). Accordingly, Edmondson & Lei (2014) emphasize the need for additional research to explore the boundary conditions that shape the effects of psychological safety.

To conclude, the concept of psychological safety was defined by Edmondson (1999, p.350) as 'a shared belief held by members of a team that the team is safe for interpersonal risk taking'. This perspective is strongly supported by research showing that psychological safety is a group-level phenomenon; perceptions tend to converge among people working closely together, and this climate varies significantly between different groups within the same organization. However, a shared belief is necessarily an aggregation of individual perceptions. The literature itself acknowledges a stream of research focusing on the individual-level experiences of psychological safety and their impact on outcomes like engagement and speaking up. Understanding the antecedents of this individual experience is a prerequisite for understanding how a collective, shared perception emerges. Therefore, our empirical research addresses this necessary micro-foundation by investigating what individual people perceive as psychological safety.

2 Research

2.1 Aims of the study

The emergence of the Industry 5.0 paradigm signals a critical shift from a purely technology-driven model to one that is fundamentally human-centric, sustainable, and resilient. This framework explicitly places the well-being of the individual at the centre of the production process. This emphasis on well-being inherently expands the traditional, objective-only definitions of safety (the absence of physical hazards) to prioritize subjective safety, an individual's internal feeling of being sheltered from psychological or material harm. This subjective dimension is increasingly recognized as a necessary precondition for fostering the innovation, resilience, and human agency central to the Industry 5.0 paradigm.

Within organizational scholarship, this concept of subjective, interpersonal safety is most robustly captured by the construct of psychological safety. At its core, psychological safety refers to individuals' perceptions of the potential consequences associated with taking interpersonal risks within a team or organizational setting (Edmondson, 1999). Research has consistently supported this, demonstrating that psychological safety is best considered a group-level phenomenon, as people working closely together form similar perceptions that differ from other groups.

However, the holistic, human-centric principles of Industry 5.0, which aim to serve humanity and society, not just the organization, imply that a sense of safety is interconnected, linking an individual's workplace experience with their wider local and community context. This suggests a need to understand the micro-foundations of this construct. Before a shared belief can emerge at the group level, each individual must first form their own subjective perception of safety. Yet, what constitutes psychological safety for an individual remains less explored. Accordingly, our study addresses this research question.

2.2 Sample and Procedure

The sample (n = 111) was composed of students from the Faculty of Advanced Social Studies (SASS) in Slovenia, enrolled in the Psychosocial Support and Social Management undergraduate programs. Data was gathered using the online survey platform 1ka over a two-month period, from December 2024 to January 2025. Participation was voluntary and anonymous.

The sample was predominantly female (84.7%, n = 94), with 15.3% (n = 17) identifying as male. Half of the participants (50%) were under 30 years of age, 39% were aged between 30 and 44, and 11% were over 45.

Regarding their education level, 62% (n = 69) reported secondary education as their highest level, 21% (n = 23) had a 1st Bologna cycle degree (bachelor's), 11% (n =12) had a 2nd Bologna cycle degree (master's), and 6% (n = 7) held a scientific master's, or doctoral degree. All of the participants were part-time students.

2.3 Measures

The data for this paper was drawn from a larger, quantitative study on psychological safety. For the purposes of this paper, only two components of the larger survey were analysed: the demographic data of the subsample (gender, age, and student status) and responses to a single open-ended qualitative question ('What does psychological safety mean to you?').

2.4 Data Analysis

This study employed a mixed-methods design, combining quantitative demographic data with a qualitative, open-ended inquiry. The data analysis was conducted in two stages.
First, all quantitative demographic data were analysed using descriptive statistics. Second, the 111 qualitative responses were analysed using an inductive, thematic content analysis. This process included open coding (codes were identified as they emerged directly from the text, independent of pre-existing theories), categorization (initial codes were then reviewed, compared, and grouped into broader, semantically-related categories, e.g., 'relationships', 'financial and material security') and frequency analysis (a frequency count was conducted for each category to determine the salience and priority of these themes). Individual responses frequently encompassed multiple categories (e.g., 'partner's support and financial stability'). A single response may therefore contribute to the frequency of several categories.

3. Results

The analysis of responses on the open-ended question revealed 136 codes that could be grouped into 7 categories (see Table 1). The participants' feeling of psychological safety is most strongly linked to interpersonal relationships. This is followed by emotional categories (support and values) and only then by material and stability factors. Internal personal factors were mentioned as well. Health comes in last place.

Table 1: Categories of Psychological Safety Derived from Open-Ended Responses.

Category	Frequency (No. of mentions)
Relationships	42
Emotional support and acceptance	37
Values of interpersonal relationships	19
Financial and material security	14
Stability and peace	13
Personal factors	7
Health	4
SUM	136

Note: The total frequency (136) is higher than the number of respondents (111) because some participants provided answers that spanned multiple categories.

1. **Relationships:** By far the most important source of psychological safety is people. Respondents explicitly mentioned partners, family members, and friends as their foundation of safety. Answers include*:* 'Partner, family, friends', 'Partner', 'Family and a positive attitude', 'The closeness of people who are important in my life'.

2. **Emotional support and acceptance** This category is closely related to the first but focuses on the actions within those relationships. It reflects the sense of having someone who stands by you, offers comfort, and provides emotional support and love. Illustrative responses include: 'That my parents stand by me and help me', 'My partner's closeness, hugs, the fact that he is 'there for me'', 'Love', This category also includes the feeling that you can be who you are, that you are accepted, and that others listen to you. For example: 'That I see signs from others that they accept me', 'a space where I feel accepted and heard', 'That I am heard, that they don't interrupt me when I speak and respect my opinion...'.

3. In third place are the fundamental **values of interpersonal relationships**. Safety stems from trust, honesty, loyalty, and a feeling of mutual respect. Answers include*:* 'Respect', 'Loyalty, respect', 'Loyalty, respect, dedication, being heard, trust, acceptance', 'Honesty'.

4. **Financial and material security:** The first category, which is not directly related to relationships, is material well-being. This includes stable finances, a regular job, and settled housing conditions (a home). Answers corresponding to this category are: 'Settled housing situation, financial security...', 'My own home, employment...', 'Regular financial income, regular job'.

5. **Stability and peace:** Respondents desire stability, routine, predictability, and peace, which also includes non-conflictual relationships and a sense of control. For example: 'A sense of stability, and having a routine...', 'Peace', 'Being in control'.

6. **Internal or personal factors**, such as ‘self-confidence’, ‘autonomy," "relying on oneself" formed this theme, as well as emotional balance and inner peace.

7. **Health**: Finally, some respondents (n = 4) mentioned health as a component of psychological safety. Health was always mentioned in connection with other factors, for example: ‘Peace, health, love’ or ‘Financial income, health, good relationships with loved ones’.

These 7 categories can be further grouped into three overarching themes:

The Interpersonal & Relational Theme (categories 1, 2 and 3): This theme identifies an individual’s core social network as the primary source of psychological safety, with participants consistently citing partners, family members, and friends as the foundation of their sense of safety. It was closely tied to the affective actions performed within these relationships, such as expressions of love, physical closeness, and the assurance of having dependable support and companionship. This theme also includes qualitative conditions necessary for social interactions to feel safe, such as the presence of fundamental values. Participants associated safety with feelings of mutual respect, trust, honesty, and loyalty, as well as with behaviours reflecting this climate — being accepted, heard, and given space to express oneself without interruption.

A second major theme is related to **Material Security & Situational Stability** (categories 4, 5 and 7), including financial and material security, such as a stable income, regular employment, and secure housing. This was often connected to a broader need for environmental stability, peace, predictability, routine and control. Health, while mentioned less frequently, was often integrated into this broader theme of stability. As can be seen, this theme represents the external, structural, and personal conditions that form a stable base for an individual’s life.

Finally, a smaller number of participants highlighted **Internal or Personal Factors** (category 6), such as self-confidence, emotional balance, or inner peace, as sources of psychological safety. This theme represents a state of safety that is not received from others or the environment, but generated from within through ability, self-reliance, and self-worth.

Overall, the results indicate that the participants’ perceptions of psychological safety are primarily relational and affective in nature and further reinforced by objective life circumstances and internal personal resources.

4 Discussion

The emergence of Industry 5.0 marks a paradigmatic shift from the technology-driven efficiency of Industry 4.0 toward a more holistic, human-centric model of industrial and organizational life. While Industry 4.0 was characterized by automation, artificial intelligence, and the optimization of production processes through cyber-physical systems (Breque et al., 2021; Majerník et al., 2022; Romero et al., 2016), it often marginalized the social dimensions of work and overlooked the human need for connection, purpose, and well-being. In contrast, Industry 5.0 repositions the human being as the central actor in production systems and reframes technology as a tool that serves people (Breque et al., 2021; Pathak et al., 2023; Zafar et al., 2024). This conceptual evolution emphasizes productivity and innovation alongside the sustainability, resilience, and dignity of the human workforce. Within this paradigm, the human is viewed as an asset whose creativity, emotional intelligence, and capacity for problem-solving are integral to organizational success (Gamberini & Pluchino, 2024; Grabowska et al., 2022).

The present study was situated within this broader transformation and aimed to explore individual's sense of safety as an important component of the Industry 5.0 vision. The WHO's dual-dimensional framework of safety (objective and subjective) provides a useful lens through which to understanding this transformation. Objective safety is verifiable and externally measurable, while subjective safety refers to the internal perception of being free from harm or threat in one's social and professional environment (Maurice et al., 1998; Nilsen et al., 2004). In Industry 4.0, safety was largely treated as an engineering and data problem to be solved, focusing on the mitigation of measurable, physical risks to the human worker. The prevailing understanding of safety in this model was primarily objective, with little recognition of its subjective dimension despite the fact that this technological focus, while reducing physical hazards, often inadvertently created new psychological threats, such as anxiety caused by surveillance, the stress of cognitive overload from an 'always-online' culture, or the existential fear of job obsolescence (Breque et al., 2021). In the Industry 5.0 paradigm, this subjective dimension gains renewed significance, as human well-being, creativity, and resilience depend on physical protection as well as emotional and psychological assurance. Within organizational scholarship, this imperative for subjective, interpersonal safety is most robustly captured by the construct of psychological safety.

Psychological safety is defined as a 'shared belief among team members that the team is safe for interpersonal risk-taking' (A. C. Edmondson, 1999). It reflects the degree to which individuals feel comfortable expressing themselves without fear of embarrassment, rejection, or punishment. This concept, initially framed as a group-level phenomenon, has been repeatedly associated with enhanced learning, innovation, and performance (e.g. Edmondson & Lei, 2014; Kark & Carmeli, 2009; Siemsen et al., 2009). However, much of the literature emphasizes collective perceptions, leaving the micro-foundations of these

shared beliefs, especially how individual people experience and interpret psychological safety, underexplored. Building on Edmondson & Lei's (2014) observation that the boundary conditions and personal antecedents of psychological safety are still underexplored, this study focuses on how individuals themselves interpret and experience safety. Accordingly, the current study explores the individual's subjective understanding of psychological safety, linking the macro-level aspirations of Industry 5.0 to the micro-level experiences of people within social systems.

The analysis of 111 qualitative responses reveal that psychological safety is a multidimensional construct, rooted primarily in three overarching themes: the 'interpersonal & relational', the 'material security and situational stability' and the 'internal or personal factors'.

The results show that individual perceptions of psychological safety are primarily relational and affective in nature, underpinned by strong interpersonal connections and emotional support. The most frequently mentioned sources of psychological safety were relationships with family, partners, and friends, which participants described as their fundamental foundation of safety. This emphasis on human relationships aligns with the human-centric ethos of Industry 5.0, which recognizes the intrinsic value of human connection and collaboration (Breque et al., 2021; Pathak et al., 2023). In these narratives, safety was conceptualized as an affective experience rooted in interpersonal closeness, trust, and acceptance. Emotional support, expressed through love, understanding, and the feeling of being heard and accepted, emerged as the second most salient category. This indicates that individuals associate safety with the assurance of acceptance and support within their close relationships. This aligns with the theoretical framework proposed by Lynch et al. (2024) that identify a Sense of Safety as a complex awareness of connection to others, specifically mentioning family, partners, and friends. They also identified sub-themes of this relational safety which include 'being heard and understood,' 'belonging,' 'trust,' and 'being treated with dignity', which alignes with our third most prominent category, the values of interpersonal relationships. Participants associated safety with relational qualities such as respect, honesty, loyalty, and trust, which form the moral foundation of safe social environments. Trusting others, feeling valued and respected reduces the fear of negative evaluation, allowing individuals to engage fully and authentically in interpersonal exchanges. As a socio-emotional resource, psychological safety allows individuals to manage perceived risks and collaborate more effectively, ultimately contributing to shared goals and higher organizational performance (Bülbül et al., 2022). Such conditions are particularly critical in environments characterized by uncertainty and interdependence, features increasingly prevalent in digitalized workplaces (Gamberini & Pluchino, 2024).

Together, these three categories (relationships, emotional support and acceptance, values of interpersonal relationships) compose a broader relational theme, suggesting that

individuals perceive safety primarily through the quality and reliability of their social networks. This finding agrees with prior theoretical models emphasizing that psychological safety within teams arises from interpersonal trust and mutual respect (Carmeli & Gittell, 2009; A. C. Edmondson, 1999; Kahn, 1990). This relational-based safety is so fundamental that its absence is linked to loneliness (Hawkley & Cacioppo, 2010),social exclusion (Baumeister et al., 2007), social pain (Eisenberger et al., 2003), and feelings of betrayal (Freyd et al., 2005). The findings also extend this logic beyond formal work settings, implying that relational safety in private and community contexts may serve as a precondition for experiencing psychological safety in professional domains.

A second overarching theme centres on material security and environmental stability. Participants frequently mentioned stable income, housing, and employment as key contributors to their sense of safety. These material foundations, while seemingly external, were often interwoven with psychological and emotional concerns, like stability, predictability, peace and a sense of control. This finding aligns with the WHO's definition of safety as both a physical and psychological condition that enables individuals to pursue their aspirations (Maurice et al., 1998). Health, while mentioned less frequently by our participants, was also integrated into this theme as a component of stability. This theme directly corresponds to the Contextual Security of the Sense of Safety Theoretical Framework (Lynch et al., 2024), which includes social determinants of health, and living conditions such as housing security. Within the Industry 5.0 framework, such structural stability can be interpreted as a prerequisite for achieving resilience, one of its core pillars (Trstenjak et al., 2025). A stable external environment reduces objective risk and allows individuals to allocate cognitive and emotional resources to creative and collaborative endeavours, which are central to human-centric work systems (Romero & Stahre, 2021).

Interestingly, while the majority of responses emphasized external or relational conditions, a smaller portion highlighted personal factors such as self-confidence, autonomy, and emotional stability. These responses suggest that some individuals derive psychological safety from internal resources as opposed to, or along with, external assurances. Such self-generated safety reflects the capacity for self-regulation and resilience, key attributes of the Operator 5.0 envisioned in the Industry 5.0 paradigm (Romero & Stahre, 2021). This perspective implies that psychological safety may emerge from social trust and external stability, and can also be cultivated through personal development and emotional self-efficacy. This aligns with the Sense of Self domain in Lynch et al.'s framework (2024), which is defined by inner attitudes of dignity, self-trust, acceptance, and worthiness. In this sense, individual agency and self-mastery complement the relational and structural determinants of safety. Conversely, a lack of this internal safety, as manifested in self-criticism or self-loathing, constitutes an inner estrangement that is inherently threatening (Lynch et al., 2024).

5 Conclusions

The empirical findings of our study offer a multidimensional picture of psychological safety that bridges the subjective and objective domains. On one hand, the strong emphasis on relationships, emotional support, and shared values reflects the subjective, internal experience of safety. On the other hand, the importance of financial and material stability represents the objective, external conditions that enable this subjective sense to flourish. The interplay between these dimensions also mirrors the WHO's two-dimensional model of safety (Maurice et al., 1998; Nilsen et al., 2004) and supports the argument that effective safety promotion must address both. Within the Industry 5.0 context, this integrated approach is crucial: a genuinely human-centric workplace must guarantee both the physical/material and the psychological/emotional security of the workforce.

Furthermore, the results highlight that psychological safety, although often treated as a group-level phenomenon, is deeply rooted in individual perceptions and personal life contexts. Even though (Edmondson, 1999) conceptualized psychological safety as a shared belief, the convergence of these beliefs within a team presupposes that individuals first experience safety personally. An organization cannot reasonably expect an employee to engage in acts of interpersonal risk-taking, such as speaking up about errors or offering creative dissent, if that individual feels fundamentally unsafe in their life (e.g., financial precarity) or their relational world (e.g., social isolation).

Our study suggests that the individual's perception of psychological safety is shaped by a broader social ecology that extends beyond the workplace. The Sense of Safety Theoretical Framework (Lynch et al., 2024) conceptualizes this by including psychological safety at work as one component of a larger contextual security. Cultivating psychological safety requires understanding it as an integral part of a broader system of human relationships and environmental conditions that sustain well-being and cannot rely solely on organizational policies. This aligns with the Industry 5.0 vision of interconnectedness, where technology, society, and individual life are seen as interdependent domains contributing to shared prosperity (Breque et al., 2021).

In interpreting these findings, several limitations should be considered. The sample size was modest (n = 111) and drawn exclusively from one faculty in Slovenia, which limits the generalizability of the results to broader populations or different educational and cultural contexts. The sample was also demographically imbalanced, being predominantly female (84.7%), which may have influenced the thematic emphasis on emotional support, trust, and closeness as central to psychological safety. In terms of age, the majority of the participants were young adults, with half under 30 years old and 39% between 30 and 44 years old, while only 11% were over 45. Because the sample was relatively young and homogeneous in age, it may not fully represent the perspectives of

older or more professionally experienced individuals, who might conceptualize psychological safety differently. Moreover, as all the participants were part-time students enrolled in psychosocial and social management programs, their academic and professional orientations may have further shaped their responses, emphasizing relational and affective aspects over structural or organizational factors. The reliance on a single open-ended question provided valuable but limited qualitative insight, restricting the depth and nuance of responses.

Despite these limitations, our study contributes to the theoretical and empirical understanding of psychological safety by situating it within the human-centric paradigm of Industry 5.0 and exploring its micro-foundations at the individual level. The results demonstrate that individuals primarily perceive psychological safety as a 'whole person' concept, rooted in a 'complex integrative awareness of self, other, and context' (Lynch et al., 2024, p. 18). This is built upon three core themes: relational and emotional foundations, external material stability, and internal personal agency. This multidimensional understanding aligns with the Industry 5.0 vision of sustainable, resilient, and inclusive development. The findings also highlight that psychological safety extends beyond the workplace, connecting individuals' experiences of trust, support, and stability across their social ecosystems. By recognizing and nurturing this interconnected sense of safety, organizations and societies can better align with the holistic, human-centric principles that define the fifth industrial revolution.

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The Virtual Reality as an Innovative Therapeutic Tool in Primary Schools

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Abstract The research paper examines the use of virtual reality (VR) as an innovative therapeutic tool to reduce school-related anxiety for children in primary school. It focuses on simulating stressful school scenarios (such as entering a new school, finding a classroom, or speaking in public) in a safe and controlled environment under the guidance of a therapist. The study aims to evaluate how effective VR is in lowering anxiety levels and to explore therapists' views towards the use of virtual reality as a therapeutic tool. Findings indicate that VR therapy can significantly reduce anxiety while also enhancing social skills and boosting self-confidence among pupils. Although therapists see VR as a valuable tool, they highlight the need for clearer guidelines to effectively incorporate it into therapeutic practices. The research highlights the importance of tailoring VR content to the needs of children with various learning and social challenges. Despite these challenges, VR represents an important step forward in therapeutic approaches, as it allows students to gradually adapt to stressful situations without pressure from the real world.

Keywords: • virtual reality • school anxiety • primary education • therapy • mental health

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https://doi.org/10.4335/2026.2.10 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Definition of virtual reality

The use of virtual reality technology represents a significant technological advance in the field of human-user interaction, as it allows the user to become completely immersed in a digitally created three-dimensional environment (Grochowska, Wichniak, & Jarema, 2019). Today's standard VR systems use either head-mounted displays (HMDs) or multi-projection environments that create realistic visual, auditory, and other sensory experiences in virtual space. Virtual reality thus provides a variety of visual and auditory stimuli and also includes tactile and olfactory sensations that allow users to experience and remember the experience as real. Although individuals are aware that this is an artificially created world, they may feel that they have truly experienced the events depicted in VR (Kim & Kim, 2020).

It is therefore a multisensory experience in which the user interacts with the digital world via a device, enabling active participation and a sense of authenticity in an artificially created space. The concept of cyberpsychology, a branch of psychology that studies the relationship between humans and digital technologies, especially computer systems, is closely related to the definition of virtual reality. The concept as we know it today was first defined by Jaron Lanier in 1986. Although technology has developed tremendously since then, the basic idea has remained the same—creating a sense of physical presence in a digital environment. Modern virtual reality is based on three key elements:

- Immersion in three-dimensional space with the help of appropriate devices (e.g., head-mounted displays)
- Interaction with the virtual environment via sensors
- Feelings of presence or the impression of being "here and now"

The user can thus enter a specially designed virtual world in which situations with high psychological value are recreated. This is particularly important in a therapeutic context, where effective treatment requires the triggering of appropriate mental and emotional responses (Grochowska, Wichniak, & Jarema, 2019).

Virtual reality is now widely used in gaming, education, and business applications, as well as in medicine—particularly in radiology, preoperative planning, image-guided surgery, and rehabilitation such as physical therapy and occupational therapy (Kim & Kim, 2020). As VR technology becomes more accessible and user-friendly, it allows individuals to create their own digital worlds with minimal investment. Connecting these environments via the internet enables global collaboration and interpersonal interaction, which significantly influences the experience of the world. Virtual reality thus represents a promising tool that offers a safe environment for exploration, therapeutic work, learning, and skill development (Asiain, Braun, & Roussos, 2022).

2 Use of virtual reality in therapeutic environments

Virtual reality (VR) is one of the most innovative technologies of our time, gradually penetrating many fields, including psychology. An important aspect of VR use is its role in the treatment of anxiety disorders (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017). Almost 160 years after the birth of Sigmund Freud, we are witnessing a period in which computer science is merging with disciplines such as psychiatry and psychotherapy. Digital technologies, including VR, are increasingly being incorporated into therapeutic and diagnostic processes, marking a turning point in the development of approaches to mental health. Virtual reality is thus establishing itself not only as a technological novelty, but also as a tool that enables a more in-depth, patient-tailored, and experiential approach (Grochowska, Wichniak, & Jarema, 2019).

Advances in technology for detecting biological signals, such as body movement or heart rate, enable the collection and analysis of data on an individual's behavior and symptoms in specific situations within a virtual environment (Kim & Kim, 2020). Research is increasingly focusing on studying the effects of VR therapies on various psychological disorders, such as depression, anxiety, social phobia, social anxiety in school settings, post-traumatic stress disorder (PTSD), autism, and impulsive behavior. In addition, VR is also used to teach relaxation techniques and reduce stress. Therapies involving virtual environments have also proven effective in treating specific phobias, such as fear of heights, flying, spiders (arachnophobia), and fear of doctors or dentists. For example, individuals with a fear of heights can gradually overcome their fear in a controlled virtual environment without actually being exposed to danger. Such forms of therapy allow patients to face their fears in a way that is safer and less psychologically stressful than real-life situations. Simulating potentially dangerous situations, such as flying or walking on a tightrope, allows patients to gradually expose themselves and learn to cope with anxiety without being exposed to physical risk (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017).

Gradually, the tool has been expanded to other disorders such as anxiety disorder, obsessive-compulsive disorder (OCD), post-traumatic stress disorder (PTSD), eating disorders, addictions, psychoses, autism, and attention deficit hyperactivity disorder (ADHD). In anxiety disorders and phobias, VR technology can help by gradually exposing the person to triggers/threats in a safe and controlled environment. For patients, facing stressful situations in such a virtual environment is less stressful. VR is effective in teaching social, cognitive, and daily living skills to children and adults with autism. Despite promising results in VR therapies, technical and financial limitations remain. The costs of developing and using VR systems are high, and therapeutic content needs to be better adapted to the specific needs of patients. In addition, more research is needed to confirm the long-term effects of therapy. Nevertheless, VR represents an important step in the development of clinical psychology (Emmelkamp & Meyerbröker, 2021).

For patients with post-traumatic stress disorder, re-exposure to traumatic events in a real-world setting is often too risky and emotionally overwhelming. The use of virtual reality in these cases allows for the creation of a controlled therapeutic environment where patients can confront their traumas in a safer context. Kim and Kim (2020) report that such forms of VR therapy are often used with war veterans (e.g., Vietnam or Iraq War) and survivors of terrorist attacks (e.g., September 11). In these types of therapies, patients use VR glasses to relive traumatic situations in a simulated environment, which allows for a gradual reduction in the intensity of emotional responses. Positive effects have also been reported in people who have experienced serious traffic accidents. The results show that the effects of PTSM therapy last from three to six months (Kim & Kim, 2020). The use of VR is also promising in the field of diagnostics. Virtual scenarios allow the simulation of realistic situations where the symptoms of mental disorders can be assessed. For example, in social anxiety disorder, VR allows the observation of characteristic patient reactions, such as avoidance of eye contact or increased anxiety in virtual social interactions. Diagnostic procedures using VR also include measurements of physiological responses such as heart rate and skin conductance, allowing for more accurate tracking of changes during therapy (Wiebe et al., 2022).

When treating autism spectrum disorders (ASD) or autism, VR is a useful tool for learning social skills and improving cognitive functions. An example of such use is the BTS-Nirvana program, which combines VR with exercises to strengthen attention, visual-motor coordination, and problem solving. Studies have shown that the combination of VR and cognitive behavioral therapy (CBT) in children with autism leads to significant improvements in social interactions, adaptability, and emotional regulation skills (De Luca et al., 2021).

Based on an analysis of numerous studies, Ghaddaripouri et al. (2021) found that professionals working with children used various forms of virtual reality tailored to the goals of each therapeutic group. In many cases, virtual reality was used as an effective distraction tool, designed to divert the child's attention away from a stressful situation and engage them in a pleasant, interactive virtual environment. In dental practice, researchers most often used VR glasses and headphones that duplicated animated worlds or playful virtual games for children. This approach allowed children to divert their attention away from feelings of pain and discomfort, which significantly contributed to reducing anxiety and improving cooperation with the dentist. Similarly, the use of VR was also effective in preoperative procedures, where children participated in interactive games, explored animated worlds, or followed soothing stories. Such experiences have been shown to reduce fear and tension associated with waiting for surgery and promote a sense of safety and control. In two studies, virtual reality was also incorporated into radiological examinations, which typically require complete immobility and therefore often cause discomfort. Children were given the opportunity to explore virtual landscapes or participate in playful activities, which helped them to relax and remain calm during the procedure. Despite the differences between the various forms and contents of VR

environments, a common feature of all approaches is the sense of authenticity and safety that the technology provides. Virtual reality offers children an attractive, often playful experience that effectively replaces or mitigates unpleasant real-life situations. It works on both a cognitive and emotional level, diverting attention away from stressful stimuli while strengthening feelings of control and relaxation (Ghaddaripouri, Mousavi Baigi, Noori, & Mazaheri Habibi, 2022).

Meditation has long been established as an effective therapeutic tool for reducing physical and psychological stress in both healthy individuals and those with various anxiety disorders. Numerous studies confirm that mindfulness programs incorporated into the school environment contribute to greater stress resilience, improved cognitive functioning, and reduced test anxiety. Recently, there has been growing interest in the use of technology in meditation practices, with virtual reality proving particularly promising. Research has shown that learning mindfulness in a virtual environment has a positive effect on individuals' emotional state and overall mental health. In addition, VR meditation programs have been rated as equally effective as traditional approaches in reducing negative moods, while proving to be more successful in maintaining motivation and regular therapy practice. Based on these findings, it is assumed that VR meditation could be a useful approach to reducing test anxiety in school-aged children and adolescents. Since previous VR programs for managing assessment anxiety were developed more than a decade ago, there is a need to re-examine their effectiveness and applicability in the modern context (Kwon et al., 2020).

3 Obstacles and opportunities for the future in the field of virtual reality

Despite its promising potential, the use of VR also has certain limitations. One of the main obstacles is the accessibility of the technology, as advanced VR devices are often expensive and require trained therapists. The high cost of advanced VR devices limits their wider availability. In addition, some patients are resistant to using new technologies, which can limit their acceptance of therapies. Another important limitation is methodological—most studies in this field have small samples and short follow-ups of long-term effects—there are no longitudinal studies (Beele et al., 2024).

In order for VR to become more widely accessible and useful, further development of technologies and research focused on standardizing protocols is crucial. For example, adapting VR therapies for more accessible devices such as smartphones and low-cost VR headsets could significantly reduce costs and increase the availability of these therapies in regions with limited resources. In addition, the use of artificial intelligence (AI) in combination with VR is a promising direction, as AI enables the personalization of therapies according to the individual needs of patients (Valmaggia, Latif, Kempton, & Rus-Calafell, 2016).

The combination of VR and AI also offers the possibility of self-directed therapies, where patients use VR applications without the direct presence of a therapist. Such therapies could be particularly useful in regions with limited access to healthcare services or for patients who avoid traditional forms of therapy due to shame or stigma. However, it is crucial that the applications are properly designed and supported by research that ensures their effectiveness and safety. In the field of eating disorders, VR offers innovative approaches to improving body image and managing food-related anxiety. By simulating various situations, such as exposure to food or viewing the body in a virtual mirror, patients can practice accepting their own bodies and develop strategies for emotional regulation. Similarly, VR is used in addiction treatment, where patients develop skills to manage triggers such as cigarettes and alcohol in a simulated environment (Freeman et al., 2017).

We can conclude that VR is a promising tool for the treatment and diagnosis of mental disorders. Its flexibility, accessibility, and effectiveness are recognized as key advantages that enable patients to safely confront their fears and improve their mental health. Nevertheless, the technology is not yet fully developed for widespread use, and further research is needed. In the future, VR could become a standard part of psychological therapies, contributing significantly to improving individuals' quality of life (Emmelkamp & Meyerbröker, 2021).

4 Virtual reality in managing school anxiety

School anxiety is a complex emotional disorder characterized by a pronounced fear of school and related situations. It most commonly manifests itself in the form of school phobia, which includes fears of specific events such as being graded, public speaking, exposure to criticism from teachers or classmates, bullying, and separation from parents upon arrival at school. These fears are often expressed on a physical level, for example, through feelings of nausea, stomach aches, or other somatic symptoms, which cause the child to persistently refuse to attend school. As a result, this can lead to significant social problems and negatively affect the child's academic performance and overall functioning. Anxiety in children often occurs during transitional periods in their educational process, such as when they start kindergarten, primary school, or secondary school. In younger children, symptoms usually appear suddenly, while in older children they develop gradually and become increasingly complex. Traditionally, behavioral and cognitive-behavioral therapeutic techniques, such as gradual exposure or social skills training, are primarily used to treat school anxiety. These approaches have proven effective in the past, but they often require a large number of therapy sessions and the involvement of additional people, such as parents and teachers. With the development of virtual reality technology, however, a new opportunity has opened up for treating anxiety disorders, including school phobia. The use of VR represents an upgrade to traditional exposure techniques, as it allows for a precisely controlled, safe, and repeatable simulation of real-life situations that trigger feelings of anxiety. In addition, the use of VR ensures greater

privacy, reduces organizational complications, and allows for gradual exposure to stimuli without the need for actual presence in the school environment (Gutiérrez-Maldonado et al., 2009).

Adolescence is a developmental period that brings increased vulnerability to mental health problems. In this context, digital mental health support, which includes various technological approaches and tools, is proving to be an important innovation with great potential to help young people and educational institutions. The use of digital technologies among young people is constantly growing and becoming part of their everyday lives, indicating that this trend will continue in the future. Technological approaches are often particularly attractive to young people because they are consistent with their developmental characteristics—curiosity, desire to explore, play, and learn. It is precisely because of these characteristics that digital tools open up opportunities for implementing preventive mental health programs in ways that are developmentally appropriate, interesting, and motivating for young people. However, technological sophistication alone is not enough to ensure the actual effectiveness of such innovations—it is crucial that they are integrated into the everyday environment of young people and are actually accessible to them. This is particularly true in the school context, where young people face various challenges such as stress, peer violence, and interpersonal conflicts. Digital innovations must therefore be designed in such a way that they enable young people to develop effective strategies for coping with stressful situations and strengthen their resilience in real life (Hugh-Jones, Ulor, Nugent, Walshe, & Kirk, 2023).

In addition to common anxiety disorders, school anxiety, which includes fears related to academic or social situations in the school environment, is becoming increasingly common among adolescents. Approximately 25% of adolescents meet the diagnostic criteria for anxiety disorders within a one-year period, with school anxiety being a common form. These problems often lead to school avoidance, poorer grades, and social isolation. In the school environment, the most common problems are fear of failure in tests or schoolwork (test anxiety), fear of social situations such as public speaking and interacting with peers, and resistance to schooling, which can manifest itself as avoidance of school attendance. School anxiety is not formally recognized as a separate diagnosis in manuals, but it is extremely similar to another disorder, social anxiety disorder. Schools often use cognitive-behavioral therapy (CBT), which is the most established approach to treating school anxiety and involves exposure techniques. This means that schoolchildren are directly confronted with situations that trigger anxiety in order to gradually reduce their fear. However, exposure in school settings requires a high level of cooperation from schools and parents, which often presents a barrier to implementing therapy. Here, an innovative solution is now being offered that would improve the current approach to exposure. Using virtual reality, the therapist can tailor the virtual situation to the individual's level of anxiety. In addition, patients who do not want to expose themselves to real-life situations are more likely to agree to participate in VR scenarios. When exposing patients to situations at school, the VR tool does not require the participation of

the school or a similar organization. Theory also provides us with mechanisms that support the effectiveness of VR therapy, namely that repeated exposure to an anxiety-provoking situation reduces emotional and physiological reactions, participants learn that the expected negative events are not so severe or do not happen at all, and that they come to realize that what will happen (expectation) is rarely related to what actually happens. VR thus creates the real experience needed to trigger anxiety. Past research on the use of VR in adults is very well documented, while research in adolescents is less so. Some studies show that VR therapy is acceptable and effective in reducing anxiety, including fear of public speaking and school anxiety. Adolescents who are not ready for live exposure often prefer VR over any other alternative method, such as cognitive-behavioral therapy (Beele et al., 2024).

Anxiety related to academic assessment is an increasingly common challenge in school settings, particularly in East Asian countries where expectations for academic achievement are extremely high. Students in such systems are often exposed to intense academic pressure, making them more vulnerable to developing various forms of anxiety disorders. Assessment anxiety refers to a persistent fear that arises in situations where an individual is subject to judgment or evaluation. It occurs in two interrelated dimensions: cognitive, which involves thought processes such as overthinking and focusing on the possibility of failure, and physiological, which manifests itself in physical responses such as rapid heartbeat, sweating, or muscle tension. Together, these responses affect an individual's emotional balance and ability to function effectively in a school setting. Recent research shows that between 15% and 22% of students experience test anxiety, with an upward trend particularly among younger children, which represents a significant challenge for school psychology and preventive mental health programs (Kwon et al., 2020).

The practical example shown in Figure 1 below illustrates four screenshots (A-D) depicting key scenes from the virtual environment used in virtual reality therapy for adolescents with school anxiety. The virtual environment was designed to gradually expose participants to simulated school situations in which they encounter circumstances that often trigger symptoms of social or school anxiety.

Picture 1: Virtual reality scenario. Panels (A; schoolyard) and (B; school hallway) are examples of the "exploration" phase (Beele et al., 2024).

Part A shows an exterior view of the school building. The participant is first confronted with a view of the school and the paved path leading to the school entrance. This scene represents the initial phase of exposure and symbolizes arrival at school, which often triggers feelings of discomfort and tension in individuals with school anxiety. Part B shows the interior of the school, where you can see a long corridor with a few students talking to each other. For individuals with social anxiety, the mere presence of peers and the possibility of interacting with them is a major challenge. This scene thus serves as the next step in gradually confronting social situations within the school environment. Elements such as the lights, the sense of depth, and the pictures on the walls further enhance the feeling of realism, which is key to the effectiveness of VR therapy. Part C shows a classroom in which several students are sitting at desks. It is designed to be realistic, with large windows, a map on the wall, pictures, and plants on the shelves. In this scene, the participant is placed at the center of attention in the classroom, which is often one of the most stressful situations for people with anxiety, as they are exposed to the gaze of all their peers at that moment. Part D shows direct interaction with the teacher. For many students with severe social anxiety, this situation is also a powerful trigger for

anxiety. This response is often associated with a fear of being evaluated, asked questions, or making a mistake in front of the whole class. The entire set of images from A to D is designed to gradually activate specific anxiety responses in the individual. At the same time, it allows the therapist to monitor emotional and physiological responses in a controlled virtual environment and gradually reduce the intensity of fear through a process of repeated exposure (Beele et al., 2024).

Although studies in the past have highlighted the prevalence of school anxiety, very few have examined the specific situations that cause anxiety and the potential use of technology such as virtual reality (VR) to reduce these problems. School anxiety is a type of anxiety that includes fear of failure, public speaking, new relationships, and unfamiliar situations. Another interesting study was conducted involving 229 fifth graders in two elementary schools. Surveys and interviews were used to identify situations that cause anxiety. The surveys included 19 situations in which students rated their level of anxiety (from "not anxious" to "very anxious"). The 20 students with the highest levels of anxiety were invited to experience VR therapy, where they participated in simulations of specific school situations. The VR situation was arriving at a new school and finding the classroom. The results showed that the most common situations causing anxiety were presenting in front of the class, solving problems at the blackboard, adjusting to new teachers and classmates, arriving at a new school for the first time, and fear of failure in assignments and tests. The effects of VR therapy showed that after the VR experience, 65% of students reported that they were no longer anxious about starting at a new school, whereas before therapy, 100% rated themselves as "very anxious." Anxiety about finding their classroom decreased significantly: 75% of students no longer felt anxious, while the rest reported a reduction in their anxiety levels. Interviews showed that after therapy, students were more confident and willing to use options such as seeking help from teachers or peers. The results thus showed that VR therapy has great potential for reducing school anxiety, especially in young students who are faced with new and stressful situations. VR provides a safe environment for gradually confronting anxiety-provoking situations and builds confidence in overcoming challenges. Although the results are promising, the study highlights the need for greater customization of VR programs and greater diversity in simulated situations. Nevertheless, the study confirms that VR therapy effectively reduces anxiety in elementary school students. Students who experienced VR showed greater willingness to face real school situations (Anh, 2020).

A study designed in two phases confirms that VR has the potential to reduce stress in the school environment. The first phase involved eighteen adolescents who participated in workshops based on the principle of "creative thinking." This approach encourages active user participation in the design of solutions, so the adolescents in the study were involved as co-creators of the therapeutic program. Together with the researchers, they designed scenarios and stories that formed the basis for the virtual experience. They suggested school situations that they found most stressful or burdensome and proposed ways in which these could be presented in a safe virtual environment. Based on these workshops,

a prototype of VRET (Virtual Reality Exposure Therapy) was developed, which means that researchers upgraded the prototype on the fly based on the responses and suggestions of the participants. In the second phase, eighteen adolescents were again included in the study, each completing one full experience in a virtual environment designed based on the previous workshops. After the session, participants completed a structured questionnaire supervised by the research coordinator to ensure uniform data collection conditions and clarify any ambiguities. The questionnaire focused on assessing the virtual experience and evaluating whether this type of therapy could contribute to reducing school anxiety. The results showed that most adolescents rated the virtual experience positively. Exposure therapy is only effective if it triggers an anxiety response, so it is encouraging that as many as 89% of participants experienced a physical response associated with anxiety during simulated school situations. In addition, 93% of participants rated the experience as immersive, meaning that they felt truly present in the virtual environment, while 94% rated the scenarios as very convincing and realistic. However, the most important finding of the study was that all participants (100%) expressed their belief that the use of virtual reality could help them cope with school anxiety, confirming the high level of acceptance and potential effectiveness of this therapeutic method among young people (Boyle et al., 2024).

Hugh-Jones and colleagues (2023) presented their research on the development and testing of a virtual reality tool designed to support the mental health of adolescents in a school setting. In the initial phase, they involved 18 mental health professionals who worked directly with young people. These included teachers, child and family specialists, and school psychologists. Later, three mindfulness experts joined the research team, contributing their experience to the design of the tool's content. Young people with previous experience of mental health problems were also involved in the research. Their role was to participate in the design of exercises whose main goal was to reduce stress by regulating emotions using mindfulness principles. The prototype was tested in two regular and one specialized educational institutions. A total of seventeen young people participated in testing the working prototype of the VR tool at school. Before testing began, mental health professionals participated in a one-day workshop where they had the opportunity to try out VR headsets and learn about the basic functioning of the system. The research was conducted in two consecutive phases. The first phase focused on developing and designing a prototype with the direct involvement of young people, while the second phase focused on field testing in a school environment. Based on feedback from experts and young people, a prototype was developed that consisted of a six-week program with twelve short eight-minute exercises. These exercises included various techniques such as body awareness, breath control, acceptance, and self-compassion, and took place in visually calming VR environments such as a forest, the sea, a park, and waterfalls. The purpose of the tool was to provide adolescents with a peaceful and safe digital space to practice mindfulness and relaxation techniques. Each participating school received one VR kit with preloaded software, which was incorporated into the students' schedule as part of their regular activities. The results of the study showed that the use of

VR in schools is acceptable to both young people and professionals, and is particularly promising for young people with more complex needs, such as difficulties in regulating emotions and attention deficit disorder with or without hyperactivity (ADHD). Participants accepted the tool well, rated it positively, and used it without difficulty, and schools also showed interest. An important finding of the study was that adolescents with more pronounced emotional and behavioral problems benefited more from the use of the VR tool than their peers without mental health problems but exposed to stress.

Picture 2: Prototype of the aforementioned environment (Hugh-Jones, Ulor, Nugent, Walshe, & Kirk, 2023).

Picture 2 shows an example of a prototype virtual environment developed as part of the research. It is an interactive VR tool in which users independently select practices based on their current mood and needs. The virtual world is designed according to the principle of a game, as it includes paths, bridges, information boards, and various points where users can choose a specific exercise. This design encourages a sense of engagement and independent exploration, as young people actively discover the environment and decide for themselves which activities they will perform (Hugh-Jones, Ulor, Nugent, Walshe, & Kirk, 2023).

5 Advantages and challenges of implementing vr in therapeutic work with children

Virtual reality (VR) often has a stronger effect on children and adolescents than on adults, as the virtual environment can draw them in more intensely and "suck" them in. Such experiences often trigger more pronounced emotional and cognitive responses in younger users, which can be therapeutically beneficial but also risky if the therapist does not have complete control over the course of therapy. Therefore, special caution and professional guidance are necessary when planning the content and implementation of VR therapies.

The authors of the article point out that so far, there has not been enough research systematically examining the link between VR use and the developmental characteristics of children and adolescents. As a result, there is still a lack of solid scientific evidence for the widespread and reliable use of VR in the pediatric population (Kim & Kim, 2020). Nevertheless, the use of virtual reality in children with anxiety disorders and social difficulties has proven to be very promising, mainly due to several specific advantages. Children who are already accustomed to interactive digital content easily accept VR as a therapeutic tool, as the experience is similar to video games. This natural affinity for technology increases their motivation and willingness to participate and reduces resistance to the therapeutic process. VR therapy enables safe learning through play—children can gradually confront situations that would cause intense anxiety or discomfort in the real world, but without the risk of actual consequences. Because the therapy takes place in a completely controlled digital environment, children can explore and practice coping with challenges at their own pace without being exposed to real dangers. One of the important advantages of VR therapy is its repeatability and uniformity—the therapist can present the same conditions to each child, from background noise control to detailed scenarios. This allows for more objective monitoring of progress and greater reliability of therapeutic assessment. In addition, the content of the virtual environment is extremely flexible. The therapist can easily adjust the level of difficulty, dynamic elements, or types of stimuli according to the child's needs and progress. Another significant added value of VR technology is the possibility of continuing therapy at home. Using customized VR software, children can independently practice the exposure and coping techniques they have learned, which reinforces the sustainability of the therapeutic effect and enables continuous improvement between therapy sessions. All of the above advantages make virtual reality a safe, flexible, and extremely attractive therapeutic tool for children, combining elements of play, control, and realistic simulation, thereby contributing significantly to the more effective treatment of anxiety and social disorders in young people (Bioulac et al., 2018).

6 Conclusion

The use of virtual reality (VR) technology in the context of mental health is one of the fastest growing areas of modern psychology and psychiatry. It is a technological breakthrough that significantly changes the way people communicate with the digital environment and opens up new possibilities for therapeutic work and learning. Virtual reality allows users to immerse themselves completely in a digitally created three-dimensional world in which they can actively participate, experience realistic stimuli, and develop a sense of authenticity in the "here and now." This type of experience creates conditions for deep emotional and cognitive responses, which is particularly important in therapeutic processes where the goal is to challenge, understand, and gradually mitigate an individual's emotional responses (Grochowska, Wichniak, & Jarema, 2019; Kim & Kim, 2020).

Over the past decade, VR has proven to be an extremely promising tool in the treatment of numerous mental disorders, such as anxiety and depressive disorders, social phobia, post-traumatic stress disorder (PTSD), autism, and impulsive behavior. Its main advantage is that it allows individuals to safely confront their fears in a completely controlled environment. The patient can gradually expose themselves to situations that would cause intense distress in real life, while the therapist closely monitors their responses and adjusts the course of therapy accordingly. This approach enables a holistic experiential treatment that goes beyond traditional verbal methods and encourages the individual's active involvement in the healing process (Maples-Keller, Bunnell, Kim, & Rothbaum, 2017).

The use of VR is particularly interesting in the population of children and adolescents, where technology allows therapeutic content to be combined with interactive elements of play and exploration. Research shows that young people are more receptive to such approaches, as they match their developmental characteristics and natural curiosity (Bioulac et al., 2018; Hugh-Jones, Ulor, Nugent, Walshe, & Kirk, 2023). The use of VR in schools and youth centers has proven to be an effective support in learning emotional regulation, reducing stress, and promoting self-esteem. Programs that incorporate elements of mindfulness and body awareness enable young people to safely recognize and regulate their emotional responses in a virtual environment. Studies show that adolescents with more pronounced problems, such as ADHD or emotional regulation disorders, have benefited particularly greatly from such programs (Hugh-Jones, Ulor, Nugent, Walshe, & Kirk, 2023).

Virtual reality is becoming increasingly prevalent in child and adolescent psychiatry, where its potential is particularly recognized in the areas of cognitive rehabilitation, attention training, social skills development, and as a support for various forms of therapy. Research indicates that VR can make a significant contribution to reducing school anxiety and improving young people's self-esteem. An example of the use of virtual exposure therapy (VRET) shows that adolescents in a safe, controlled virtual environment experienced realistic responses to typical school situations, such as arriving at school, interacting with peers, being present in class, and talking to a teacher. The design of such environments allows the therapist to systematically monitor the individual's reactions and gradually reduce the intensity of fear (Beele et al., 2024; Boyle et al., 2024).

Despite its many advantages, challenges remain. Key limitations include a lack of long-term research on the effectiveness of VR therapies in children, ethical issues regarding the use of technology in younger populations, and the need for adequate training of professionals working with VR tools. Further research is needed to examine more closely the impact of VR on the developmental characteristics of children and adolescents and to examine the extent to which the effects of the virtual environment are transferred to real life (Kim & Kim, 2020).

We can conclude that VR represents an important step forward in the direction of an innovative and experiential approach to mental health. It offers opportunities for a more accessible, safe, and tailored form of assistance that appeals to young people in a way that is closer to them and technologically modern. With proper implementation and professional supervision, VR can become a valuable tool not only in a therapeutic context, but also in a preventive and educational context. Its role is likely to grow in the future, as it combines scientifically based approaches to psychology with the potential of digital technology. It represents a bridge between the real and virtual worlds, opening up new avenues for understanding and strengthening mental health.

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A Psychological Integration Model for Local Strategies toward a Sustainable Human-Centric Transformation

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Abstract Industry 5.0 repositions technology in European industry by prioritising human wellbeing, resilience, and sustainability. This chapter develops a framework to operationalise the human-centric vision by integrating Lewin's field theory, vertical (adult) development and the Job Demands–Resources (JD-R) model, supported by Human Digital Twin (HDT) technology. The resulting Field Development Demands (FDD) loop captures systemic forces (field theory), differentiates meaning-making capacities (vertical development), and assesses working conditions, while HDTs enable real-time detection, modelling and adaptation. Three exemplar scenarios demonstrate the application in different European contexts. Ethical and governance issues, including data protection, autonomy, fairness, and participatory control are emphasised as essential safeguards. Industry 5.0 is not presented as a static optimisation, but as a dynamic co-evolution between people and environments, expanding collective capacity for complexity. By linking theory, practise, and technology, the chapter outlines actionable strategies that promote worker development, organisational resilience, and sustainability.

Keywords: • Industry 5.0 • human digital twin • job demands–resources model • vertical development • Lewin's Field Theory

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https://doi.org/10.4335/2026.2.11 ISBN 978-961-7124-30-9 (PDF)
Available online at http://www.lex-localis.press.

1 Introduction

Industry 5.0 represents a paradigmatic shift in European industrial policy and practise. In contrast to Industry 4.0, which focused on automation, efficiency, and technological optimisation, Industry 5.0 puts human well-being, resilience and sustainability at the forefront, placing workers' well-being, creativity, and personal purpose at the heart of industrial systems (Breque et al., 2021). At its core, Industry 5.0 is about technological advances serving human development and not simply displacing or replacing human labour. Workers are seen as co-creators of value and active participants in shaping their environment. This vision requires workplaces to evolve from one-size-fits-all models to personalised, adaptable systems that take human variability into account. Rather than simply minimising stressors, Industry 5.0 aims to create conditions that actively promote resilience, learning, and meaning-making. It is in line with the broader policy themes of the European Union (EU): inclusive growth, social innovation, and regional resilience (Breque et al., 2021).

The chapter builds on the realisation that while Industry 5.0 is widely discussed in strategic policy documents and academic debates, there is still a lack of clarity on how to translate this vision into actionable strategies at the local level. SMEs, city administrations, and municipal training centres often lack conceptual and operational tools to integrate the human dimension into daily practise. There is a need for a comprehensive, theory-led framework based on the depth psychological models of human development. This is because the work environment is a complex space in which professional demands interact with individual skills and resources. A modern, sophisticated approach should therefore take into account the dynamic interaction between the individual and their environment, which functions as a continuous feedback loop and influences long-term professional development.

This challenge is addressed by integrating three established theories: Lewin's field theory (Lewin, 1951), vertical (adult) development theory (Kegan, 1994; Cook-Greuter, 2004), and the Job Demands Resources (JD-R) model (Demerouti et al., 2001; Bakker & Demerouti, 2007). We introduce the Field Development Demands (FDD) loop, a system-level model that combines these theories into an operational framework for Industrie 5.0 workplaces. Together, these theories form a powerful lens for analysing how local Industry 5.0 strategies can improve both productivity and human wellbeing. To enable real-time adaptation, we propose Human Digital Twin (HDT) technology as the infrastructural backbone. Case studies from SMEs, public administration, and community-level initiatives illustrate practical local strategies.

The chapter contributes to theory and practise by: (a) formulating a conceptual synthesis that links psychology, organisational science, and technology; (b) presenting a dynamic model (the FDD loop) that integrates human resource development and systemic

adaptation; and (c) providing case-based insights into local Industry 5.0 strategies. By going beyond traditional management approaches, this chapter shows how European organisations can translate policy aspirations into concrete, people-centred practises that improve resilience and sustainability.

2 Conceptual Foundations

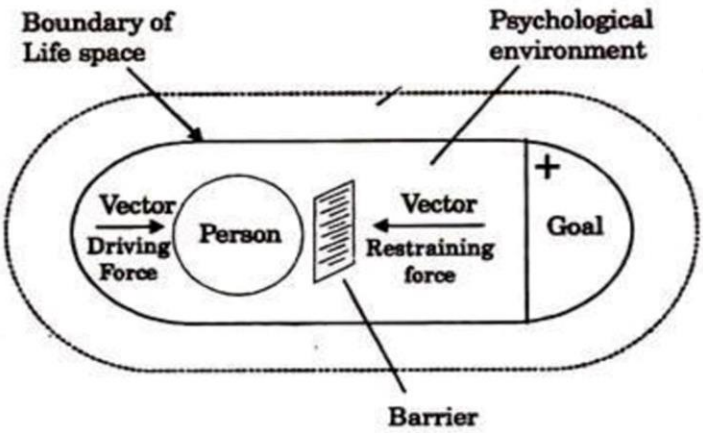
2.1 Lewin's Field Theory

To realise Industry 5.0's vision of human wellbeing, resilience, and sustainability, robust psychological theories are required to understand how individuals interact with their environment to influence motivation, performance, and development. One of the most enduring frameworks in this regard is Kurt Lewin's (1936, 1951) field theory, which understands behaviour as a function of both the person and the environment within a dynamic life space. The relevance of Lewin's field theory to Industry 5.0 focuses on how concepts such as life space, force fields, and quasi-stationary equilibrium influence the design of human-centred, adaptive and holistic work systems. It argues that technology in industrial contexts, should be seen as a field regulator capable of amplifying driving forces and reducing restraining forces to improve worker wellbeing and resilience.

2.1.1 Core Principles

Lewin summarised his view in the equation: $B = f(P, E)$, where behaviour (B) is a function of the person (P) and the environment (E). Central to this framework is the concept of life space — the set of factors that influence a person's behaviour at a particular point in time (Lewin, 1936). The life space includes personal goals, past experiences, current judgements and environmental conditions. Within this field, several psychological forces operate simultaneously, some as driving forces that propel action, others as restraining forces that prevent movement (see Figure 1).

Figure 1: Lewin's Field Theory of Learning (Lewin, 1951)



A change in behaviour occurs when the force field is altered: either by increasing the driving forces, decreasing the restraining forces, or by a combination of both. Lewin emphasised that the equilibrium is dynamic, and described it as a quasi-stationary equilibrium. When new or unmet needs destabilise the equilibrium, changes occur until a new balance is reached (Lewin, 1947). This principle is particularly relevant to the rapid changes in today's workplaces, where digitalisation and sustainability goals are continuously reshaping the psychological field.

2.1.2 Life-space, dynamic equilibrium and change in work environments and Industry 5.0 system design

The life space provides a holistic lens through which behaviour can be analysed. All psychological phenomena (thinking, acting, hoping, and perceiving) must be understood as functions of the life space (Deutsch, 1968). For organisational design, this means avoiding reductionism and instead analysing the situation in its entirety. In the workplace, this includes tasks, roles, relationships, technologies, and cultural norms. For example, team projects, digital collaboration platforms, and informal interactions (e.g., coffee breaks) are all part of an employee's life space. These elements are linked by vectors that reflect preferences and relational qualities (e.g., favouring meetings over emails, collaborative over solitary work). In Industry 5.0, driving forces can be autonomy, opportunities to utilise skills, social support, purpose and meaningful feedback; restraining forces can be cognitive overload, ambiguous goals, rigid hierarchies, digital fragmentation, or technostress.

Understanding life-spaces enables organisations to anticipate behaviour and adapt environments to human needs. In Industry 5.0, for example, this means recognising that technologies not only structure workflows, but also actively shape psychological experiences by influencing perceptions of autonomy, connectedness and purpose, and acting as dynamic field regulators. For example, adaptive AI dashboards can reduce cognitive overload by focussing information, while collaborative platforms can amplify driving forces such as connectedness and feedback. By continuously tuning the field, organisations can promote their resilience and wellbeing.

Lewin's concept of quasi-stationary equilibrium has a close connection to Industry 5.0. Work systems are not static, but evolve through cycles of stability and disruption. The equilibrium is disrupted by technological innovations, environmental crises, or new employee needs, and restored through adaptive reorganisation. Industry 5.0 environments need to embrace this dynamic rather than resist it, and view equilibrium as a process rather than a fixed state. For example, the introduction of Human Digital Twins (HDTs) can destabilise old equilibria by shifting the balance of demands and resources. However, when integrated responsibly, HDTs can help restore balance by providing adaptive feedback that reduces the restraining forces and strengthens the driving forces.

2.1.3 Applications for Industry 5.0 Workplaces

Lewin's theory can serve as a guideline for various applications of the Industry 5.0 strategy. A systemic assessment using force field analysis should be conducted to identify the driving and restraining forces in the workplace to guide interventions at a personal and systemic level (Burnes & Bargal, 2017). Human-centred design should create environments that are not only physically efficient, but also provide psychological benefits — safety, autonomy, clarity, connectedness and growth. Adaptive technology integration should position technologies as active participants in the field, and influence how employees perceive demands and resources. Change management should include an understanding of transitions as shifts between quasi-stationary equilibria, with a focus on managing the psychological forces underlying resistance and adaptation.

The integration of Lewin's field theory into organisational strategy implies several shifts:

- From structure to system: designing workplaces as responsive, living systems rather than static infrastructures.
- From control to co-creation: employees are not passive recipients, but active players who shape and reshape their environment.
- From standardisation to differentiation: recognition of psychological diversity as a design parameter.

Organisations need to move towards flexible, sensor-equipped and human-centric systems that enable real-time adaptation of the environment. This supports not only

performance, but also deeper psychological needs — autonomy, competence, and connectedness.

2.2 Vertical (Adult) Development

Industry 5.0 emphasises the integration of human capabilities and values into industrial systems, and thus goes beyond the efficiency-driven paradigm of Industry 4.0. A key aspect of this change is the realisation that employees are not static resources, but evolving individuals with different skills in dealing with complexity, perspective-taking, and meaning-making. Vertical (adult) development theory provides a framework for understanding how individuals' cognitive and emotional abilities expand over time, influence the way they interpret experiences and deal with challenges in the workplace (Kegan, 1994; Loevinger, 1976; Cook-Greuter, 2004).

In this chapter, the theory of vertical development is embedded in the conceptual foundations of Industry 5.0. It argues that understanding and promoting vertical development is essential to building resilient, adaptable and human-centred workplaces. By empowering workers and leaders to embrace complexity and ambiguity, organisations can create conditions that promote both human wellbeing and sustainable innovation.

2.2.1 Horizontal vs. Vertical Development

Developmental theories distinguish between horizontal and vertical growth (Cook-Greuter, 2004). Horizontal development refers to expanding skills and knowledge within a given stage, such as learning new technical competencies without fundamentally alter perspective-taking. Vertical development, by contrast, involves qualitative transformations in how individuals construct meaning, interpret reality, and navigate complexity (Kegan, 2016).

While most organizations have emphasized horizontal training programs, Industry 5.0 workplaces must create scaffolding for vertical development. This includes reflective practices, mentoring, feedback systems, and environments that challenge individuals to reconsider assumptions and broaden perspectives.

2.2.2 Ego Development and Action Logics

Vertical development is modelled by Loevinger's (1976) and Cook-Greuter's (2004) theory of ego development, which describes nine stages of development (see Table 1), that can be divided into pre-conformist, conformist, and post-conformist stages. In each stage, the individual develops new ways of making meaning, which are expressed through characteristic logics of action (Torbert, 2004). These logics of action influence how people interpret demands, goals, and relationships. In the pre-conforming stages (1–3), a

person is focussed on themselves and is driven by immediate needs and impulses. In the conformist stages (4–5), a person is guided by social rules, group membership and external expectations. In the post-conformist stages (6–9), a person is capable of self-responsibility, systemic reflection, and the integration of contradictory perspectives.

Table 1: Stages of ego-development (Schneider et al., 2019)

Stage	Character	Cognitive Style	Interpersonal Style	Conscious Preoccupations
E1: Symbiotic	-	-	Symbiotic	Self- vs. nonself
E2: Impulsive	Impulsive	Stereotyping Conceptual confusion	Egocentric, dependent	Bodily feelings
E3: Self-protective	Opportunistic	Stereotyping Conceptual confusion	Manipulative way	Trouble control
E4: Conformist	Respect for rules	Conceptual simplicity	Cooperative loyal	Appearances behavior
E5: Self-aware	Exceptions allowable	Multiplicity	Helpful Selfaware	Feelings problems adjustment
E6: Conscientious	Self-evaluated standards, selfcritical	Formal operations	Intense responsible	Motives traits achievements
E7: Individualist	Tolerant	Relativism	Mutual	Individuality development roles
E8: Autonomous	Coping with conflict	Increased conceptual complexity, complex patterns, toleration for ambiguity, broad scope, objectivity	Interdependent	Self-fulfillment
E9: Integrated	Reconciling inner conflicts, renunciation of unattainable	increased conceptual complexity, complex patterns, toleration for ambiguity, broad scope, objectivity	Cherishing individuality	Identity

Few people reach the highest level of development, but progression improves the ability to tolerate ambiguity, solve complex problems, and lead adaptively. The highest level

reached often acts as the individual's centre of gravity, and guides typical responses, although previous patterns may resurface under stress (Hy & Loevinger, 1996).

2.2.3 Relevance for Human-Centric Strategy of Industry 5.0

Research underlines the practical importance of vertical development in the work and organisational environment at different levels and aspects of the work process (leadership, entrepreneurship, workplace design). In line with the Industry 5.0 goal of treating employees as co-creators of value rather than passive resources, development-orientated interventions promote resilience, adaptability, and engagement. Vertical development is particularly relevant for Industry 5.0, as workplaces are increasingly characterised by complexity, rapid change, and ethical dilemmas. Employees and managers at different stages of development assess demands and resources differently. Leaders who develop vertically are better able to tackle systemic challenges, innovate, and build resilient organisations (Jones et al., 2020; Petrie, 2014). Higher levels of development correlate with a stronger innovation orientation among entrepreneurs (Schneider et al., 2019). A challenging workload can feel overwhelming for someone in a conformist stage, while it is energising for a post-conformist person who sees it as an opportunity for growth. Autonomy may be perceived as empowering by a self-empowered person, whereas it may be perceived as ambiguous or stressful by someone who is in an earlier stage. Industry 5.0 thus requires tailoring interventions to developmental stages. Structured, rule-based guidance may suit earlier stages, while reflective prompts and scenario-based simulations may benefit those in later stages. Without such customisation, the measures run the risk of being ineffective or counterproductive. Organisations implementing Industry 5.0 strategies should integrate a vertical development framework into their training and HR systems. Practises such as mentoring, coaching, reflective dialogues and deliberate developmental organizations (Kegan et al., 2016) can foster environments in which employees continuously expand their meaning-making capabilities.

Industry 5.0 emphasises that sustainable competitiveness depends on the development of people in adaptable, resilient, and inclusive workplaces. The theory of vertical development explains how workers gradually develop the ability to deal with complexity, ambiguity, and ethical tensions. By fostering this development, organisations empower their employees to see challenges as opportunities, integrate technology into meaningful work, and develop creativity, ethical judgement and systemic thinking.

This perspective complements frameworks such as Lewin's field theory and the job demands and resources model by showing how individual development shapes the interaction between person and environment. For Industry 5.0, where workers are co-creators of value, vertical development is essential for fostering resilience, innovation, and ethical responsibility. Embedding such practises ensures that technology enhances

rather than diminishes human potential, and aligns industrial strategy with human-centred growth.

2.3 The Job Demands–Resources (JD-R) Model in the Context of Industry 5.0

To operationalise the goals of Industry 5.0 - human wellbeing, sustainability, and resilience, - organizations need a theoretical framework that explains how the work environment influences employee motivation, engagement, and health. The Job Demands–Resources (JD-R) model provides such a framework. It conceptualises how the balance of demands and resources determines employee outcomes, providing actionable insights for the design of human-centred workplaces (Demerouti et al., 2001).

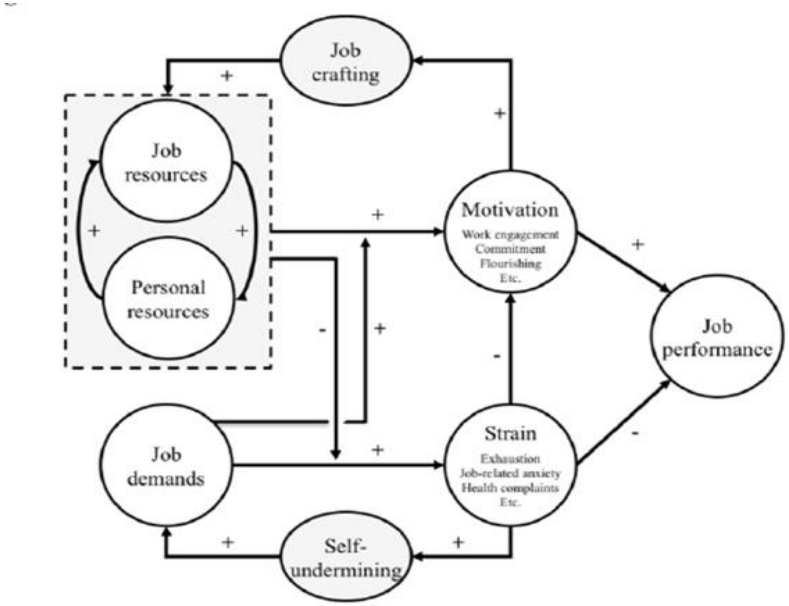
In this chapter, the JD-R model is used in the context of Industry 5.0 both as an analytical tool and as a design framework. It shows how digital transformation is changing demands and resources, and how personal and organisational measures can ensure that technology promotes rather than undermines human well-being.

2.3.1 Core Principles of the JD-R Model

In the JD-R model, a distinction is made between job demands and job resources (Bakker & Demerouti, 2007). Job demands include physical, psychological, social, or organisational aspects of work that require sustained effort, such as workload, emotional strain, role ambiguity, and digital interruptions. Job resources are aspects of work that facilitate goal achievement, reduce demands and their costs, or promote learning and development, such as autonomy, social support, performance feedback, and growth opportunities.

Demands overload predicts stress and burnout, while resources predict motivation and engagement (Schaufeli & Bakker, 2004). Resources buffer the negative effects of demands, and at the same time promote personal development. Personal resources such as self-efficacy, resilience, and optimism mitigate these relationships by enabling employees to mobilise resources and perceive demands as challenges (Xanthopoulou et al., 2007), which subsequently leads to better job performance (see Figure 2).

Figure 2: The Job Demands-Resources Model (Bakker & Demerouti, 2018)



Later developments distinguish between hindrance demands and challenge demands (Van den Broeck et al., 2010). Hindrance demands (e.g. excessive bureaucracy, unclear roles, or contradictory demands) primarily sap energy and reduce motivation. Challenge demands (e.g. high workload or responsibility), while demanding, but can also promote coping, learning, and growth. This distinction emphasises the dual role of demands in shaping outcomes and is in line with Industry 5.0's focus on turning potential stressors into development opportunities. In this way, the JD-R model can be used as a human resource management, tool that identifies the strengths and weaknesses of individuals, work groups, departments, and organisations as a whole (Chen et al., 2017).

2.3.2 JD-R in Digitalized Work Environments and Resilience of Industry 5.0

Industry 5.0 jobs introduce new categories of demands and resources (Scholze & Hecker, 2024):

- Digital Job Demands: technostress, algorithmic management, constant availability expectations, and information overload.
- Digital Job Resources: Adaptive AI coaching platforms, collaborative decision-making tools, real-time feedback dashboards, and digital autonomy enablers.

This demonstrates the flexibility of the JD-R model and emphasises its relevance for Industry 5.0 contexts. When integrated into adaptive systems such as Human Digital Twins, JD-R assessments can guide real-time adjustments that maintain wellbeing.

Resilience is a cornerstone of Industry 5.0, and is defined not only as individual toughness but as a co-created capability of systems and people. The JD-R model complements resilience theory by demonstrating how resources (e.g., autonomy, support) and personal capabilities (e.g., optimism, cognitive flexibility) enable adaptive coping strategies. Organisations can strengthen resilience by continuously monitoring demands and resources, designing interventions that rebalance the system when stresses accumulate, and fostering developmental growth by viewing certain demands as challenges. This approach ensures that resilience is embedded in the design of socio-technical systems and is not left to individual coping alone.

The JD-R model can serve as a guide for several practical applications in various areas of Industry 5.0:

- Human Resource Management: the JD-R model provides a structured diagnostic tool to identify risks and opportunities at the individual, team, and organisational levels (Chen et al., 2017).
- Technology integration: Embedding JD-R monitoring in digital platforms enables continuous feedback loops that support adaptive interventions.
- Customised interventions: Combining JD-R with a vertical developmental framework ensures that interventions are appropriate for the developmental stages of employees.
- Cross-cultural flexibility: Empirical studies confirm the applicability of the JD-R model in different professional and cultural contexts, making it suitable for multinational Industry 5.0 strategies (Schaufeli & Taris, 2013).

By distinguishing between demands and resources and clarifying their interactive effects, the JD-R model provides a measurable and adaptable framework for designing human-centred workplaces. Extending the model to include digital demands and resources ensures its continued relevance in an era of technological change. Integrating JD-R into Industry 5.0 systems enables organisations to move from reactive to proactive strategies, and ensure that technology serves as a catalyst for resilience, engagement, and human wellbeing.

2.4 Human Digital Twins as Enablers of Industry 5.0

Within the Industry 5.0 paradigm, technology becomes an enabler of human capabilities — creativity, empathy, moral reasoning, and complex decision-making — rather than a substitute for labour (Wang et al., 202). A central concept enabling this is the Human Digital Twin (HDT): a digital counterpart of a human capable of sensing, modelling and

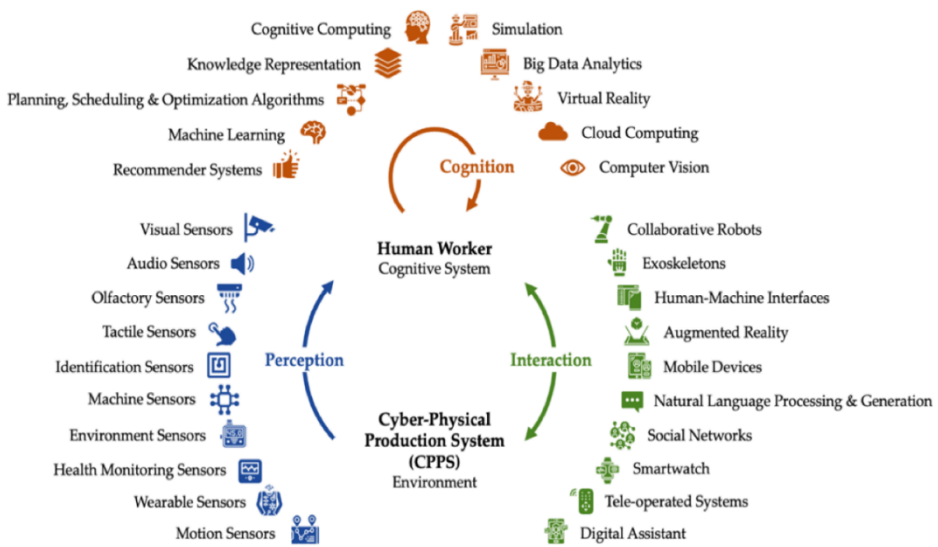
responding to cognitive, emotional, and physiological states in real time (Gaffinet et al., 2025).

This chapter examines HDTs as the human interface of cyber-physical-human systems. It emphasises their role in adaptive feedback loops that promote worker well-being, development, and resilience.

2.4.1 Defining Human Digital Twins

The concept of the digital twin originally comes from engineering as a virtual representation of physical systems for monitoring and optimisation (Grieves & Vickers, 2017). Applied to humans, this results in the Human Digital Twin (HDT): a computer model that integrates multimodal data — physiological, cognitive, emotional, and behavioural — into a dynamic representation (Wang et al., 2023, see Figure 3).

Figure 3: Symbolic human-machine relationship in the Industry 5.0 (Longo et al., 2020)



Gaffinet et al. (2025) distinguish three levels of human representation:

- Human Digital Models (HDMs): Static, descriptive profiles (e.g., ergonomics, job roles).
- Human Digital Shadows (HDS): Data-driven, real-time representations that reflect the current state and have no predictive power (e.g., fatigue or stress tracking).

- Human digital twins (HDT): Bidirectional, adaptive models that simulate scenarios and deliver personalised interventions.

HDTs differ from traditional monitoring by enabling personalisation, augmentation, and collaboration. Workers become active participants in cyber-physical-human ecosystems, and not just 'black boxes' Crucially, HDTs prioritise augmentation over monitoring and empower human agency in Industry 5.0 workplaces. For Industry 5.0, true HDTs offer the greatest potential, by integrating job demand and resource (JD-R) assessments, tailoring interventions to developmental stages, and dynamically balancing psychological forces in line with Lewin's field theory.

2.4.2 Technical Architecture for organizational human-centric applications

A generic HDT architecture for organisational contexts comprises four functional layers (Kumar et al., 2025; Wang et al., 2023):

1 Sensing Layer: collects physiological (e.g., heart rate variability), cognitive-behavioural (e.g., typing patterns, task switching), contextual (e.g., workload), and self-reported data.
2 Modelling layer: Integrates multimodal data with psychological frameworks (JD-R, vertical development). Machine learning estimates states (e.g., risk of fatigue).
3 Simulation layer: Tests "what-if" scenarios (e.g., changed workload or autonomy, based on Lewin's force field analysis).
4 Intervention layer: Provides adaptive responses (e.g., redistribution of tasks, micro-breaks, development coaching, personalised learning modules).

This architecture positions HDTs as active regulators of the working environment, continuously shaping person–environment interactions to advance Industry 5.0 objectives. For example, they can recognise early indicators of burnout (e.g.increased workloads or physiological stress markers) and suggest preventative measures like micro-breaks, peer support, or stress reduction practises, to ensure employee wellbeing (Gaffinet et al., 2023). Personalised micro-learning tailored to employees' developmental stages further enhances learning and growth, supporting both horizontal skill acquisition and vertical meaning-making (Kegan et al., 2016). In terms of safety and resilience, HDTs enable the simulation of human–machine interactions, identifying unsafe patterns (e.g., fatigue-related errors), and adapting machine parameters to prevent incidents. Such capabilities strengthen organizational resilience by anticipating risks and proactively realigning workflows (Choi et al., 2022). Collectively, these applications highlight HDTs as pivotal enablers of human-centric vision of Industry 5.0.

3 The Field–Development–Demands (FDD) Loop in the Context of Industry 5.0

To follow the Industry 5.0 paradigm, which places human wellbeing, resilience, and sustainability at the heart of industrial systems, organisations need integrative frameworks that align psychological theories, development models, and adaptive technologies. We propose the Field Development Demands (FDD) loop which integrates Lewin's field theory, vertical (adult) development and the job demands and resources (JD-R) model into a recursive process, supported by human digital twins (HDTs) as technological enablers.

In this chapter, the conceptual and practical foundations of the FDD loop are developed. It shows how technology can act as a field regulator, how developmental stages shape responses, and how recursive cycles promote both immediate adaptation and long-term developmental growth.

3.1 Core Structure of the FDD Loop

The FDD loop comprises six interconnected phases (see Figure 4):

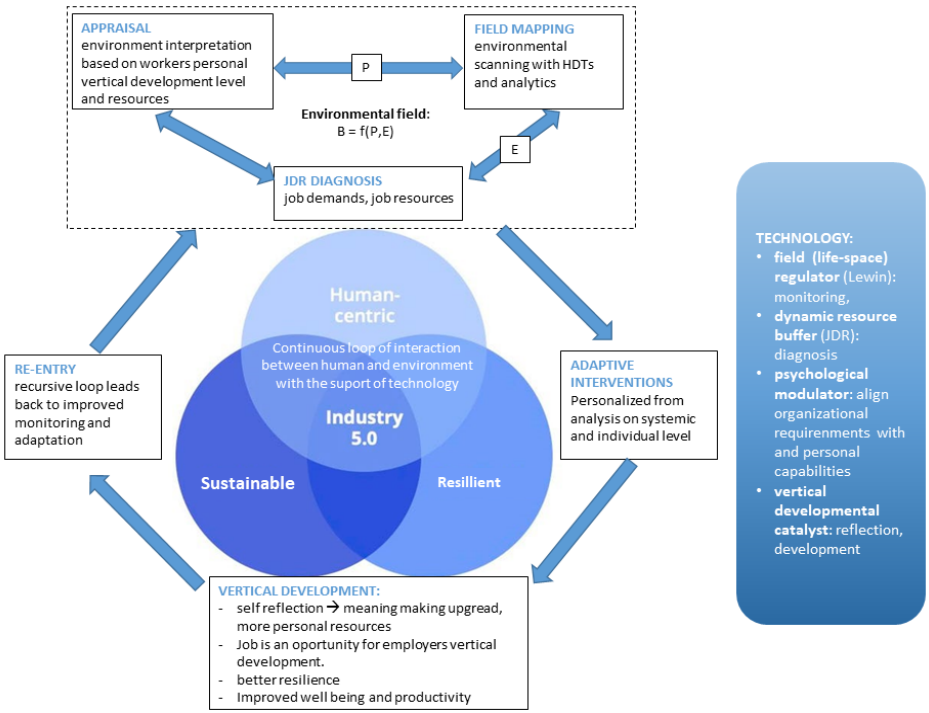
1. Field Mapping (E): environmental scanning with HDTs and analytics. Following Lewin's field theory, the workplace is viewed as a dynamic system of interacting forces shaping behaviours such as learning, safety, and innovation. Organisations identify driving forces (e.g., autonomy, feedback, support) and restraining forces (e.g., overload, ambiguity, fragmentation).
2. Evaluation (P): Individuals interpret the perceived conditions (environment) on the basis of their personal resources (self-efficacy, optimism, psychological capital) and their vertical level of development. For example, lower-stage action logics may perceive a high workload primarily as a threat, while individuals at a higher level can integrate complexity as an opportunity for growth.
3. JD-R diagnosis: Based on the JD-R theory, which states that work performance and well-being depend on the balance between job demands (e.g., workload, multitasking) and available resources (e.g., autonomy, learning opportunities, peer support) (Bakker & Demerouti, 2007), the assessment of them is performed.
4. Adaptive intervention: Based on the recorded states and assessment, interventions are made at both systemic and individual level. Based on the collected data and assessments, adaptive systems can redistribute tasks, adjust the pace of work or provide customised feedback— - thus changing the balance between resources and demand. At the same time, individuals engage in job crafting(e.g., renegotiate boundaries, seek feedback, adapt workflows), leveraging the autonomy and transparency offered by Industry 5.0 tools. This dual adaptation operationalises Lewin's principle of field regulation. This is the dynamic centrepiece of the FDD control loop that supports Industry 5.0 visions of cyber-physical systems that evolve

through real-time feedback from human operators. It is based on an iterative, feedback-driven evolution, that combines human and systemic intelligence. The workplace itself should be viewed as a two-way feedback loop that influences both personal growth and environmental change. Individuals are constantly interpreting and responding to their environment, which in turn evolves based on these responses. Technology, when integrated appropriately, can reinforce these cycles.

5 Vertical development (growth): A key innovation of the FDD loop is that it tailors interventions not only to the demands and resources, but also to the meaning-making abilities and vertical development levels of workers. This represents the assessment of the workers' developmental order, e.g., whether they start from a socialised, self-authorising or self-transforming mind. From this assessment, we can predict how each individual will assess and respond to field forces, facilitating customised interventions. For example, feedback can be provided in different ways — structured, directive prompts for socialised people, reflective cues for self-determined people, and meta-framing for people who are changing themselves (Kegan et al., 2016).

6 Reintegration: outcomes such as engagement and wellbeing are monitored. As developmental capacity increases, the environment is perceived differently, altering subsequent cycles. The forces of the field are remapped: Increased driving forces (e.g., perceived support) and decreased restraining forces (e.g., cognitive overload) gradually shift the field, in line with Lewin's theory, promoting sustained behavioural and developmental change This recursive dynamic means that behaviour (B) evolves over time as a function of the person and the environment. As the person's developmental capacity expands, the same environment (E) is now experienced differently — demands are reformulated, resources are mobilised more effectively. Over time, this contributes to organisational resilience and is in line with the goal of Industry 5.0 to achieve continuous co-evolution between people and technology.

Figure 4: The Field-development-demand (FDD) loop



Data on the different phases of the FDD cycle can be collected using both quantitative and qualitative methods. Job demands, job resources, burnout, and engagement can be assessed using standardised instruments from the JD-R framework, such as the Utrecht Work Engagement Scale or the Maslach Burnout Inventory. Vertical stages of development can be determined using validated measurement tools such as the Sentence Completion Test (SCT), the Leadership Development Framework (LDF), or reflective development diaries that capture changes in meaning-making skills over time. To monitor real-time states, physiological and behavioural data — such as heart rate variability, sleep quality, task switching frequency, and workload metrics — can be captured using (HDTs. In addition, qualitative approaches such as interviews and focus groups offer insights into subjective experiences with development measures, cultural interpretations of job demands and resources, as well as perceptions of HDT-supported procedures.

The resulting data should be analysed within a multi-layered framework: (1) at the individual level, focusing on personal resources, developmental status, and indicators of

well-being; (2) at the team and organisational level, assessing collective engagement, collaboration, and resilience; and (3) at the systemic level, assessing long-term outcomes such as employee retention, innovation capacity, and community resilience.

By embedding recursive cycles, the FDD loop enables both short-term adaptation and long-term development. Workers not only cope with stress, but gradually evolve in their ability to deal with complexity. Together, they represent a cyclical process in which individuals and environments co-evolve through adaptive feedback and technological mediation. This loop highlights that Industry 5.0 is not a static optimisation, but a dynamic co-evolution between humans and the environment. It is not just about balancing stress and engagement, but about gradually improving the system's capacity for complexity.

3.2 The Role of Technology in the FDD Loop

In Industry 5.0, technology is not a neutral tool, but an active participant in the psychological and organisational sphere. In the Field Development Demands (FDD) loop, technology acts as a field regulator, resource buffer, and development framework. It continuously modulates the interaction between people and the environment, helping organisations to balance job demands with resources while promoting vertical development and human well-being (Breque et al., 2021; Gaffinet et al., 2025). Technology enables every stage of the FDD loop:

- Monitoring with sensors, HDTs, wearables to detect work stress, fatigue, cognitive overload, etc.
- Diagnosis with AI dashboards, JD-R analyses to detect an imbalance between needs and resources or to assess the vertical stage of development.
- Adaptation through redistribution, of tasks and breaks to dynamically adjust and balance the workflow. Smart environments adjusting lighting, acoustics, and work pace based on detected fatigue or concentration levels. AI-driven task prioritisation can reduce cognitive overload by automating repetitive tasks. Workflow-based digital twins simulate peaks in demand and enable organisations to proactively reallocate resources.
- Reflection with AI reflection prompts, simulations to customise feedback loops. Adaptive interfaces tailored to employees' cognitive styles, reduce overload and improve concentration. Vertical development with customised instructions: In the early stages, employees can be reminded to take breaks or reassign tasks, while in the later stages they
- can be prompted to think with reflection prompts. In this way, technology helps sustain equilibrium by balancing restraining and driving forces in the field.
- Development with virtual/artificial reality enhances experiential learning. Dashboards that integrate purpose-driven metrics (e.g., Ikigai-inspired tools) promote alignment between personal and organisational goals and improve vertical growth. Personalised coaching applications promote self-efficacy, resilience, and

autonomy. On-demand learning platforms (e.g., LinkedIn Learning, Coursera) provide just-in-time development opportunities, reinforcing resources to buffer demands. Reflective AI tools encourage self-questioning, simulations allow employees to immerse themselves in ethically complex scenarios

- A recursive loop leads back to improved monitoring and adaptation.

In line with Lewin's field theory, technology shapes the "life space" of employees by structuring experiences of autonomy, competence, connectedness and meaning. In resource-constrained contexts, technology also acts as a psychological modulator, making incremental adjustments to align organisational requirements with individual capabilities, in line with Industry 5.0 principles of inclusivity and sustainability. Beyond regulation, technology acts as a dynamic resource amplifier within the Job Demands–Resources model (Bakker & Demerouti, 2007), which strengthens resilience, self-efficacy, and adaptability by redistributing tasks, automating routine processes, and providing timely development opportunities. These systems ensure that employees experience demands not just as hindrances but as challenges that foster growth. Technology also contributes to vertical development by promoting sense-making, perspective-taking, and the alignment of personal and organisational goals through reflection and experiential learning mechanisms (Kegan, 1994; Cook-Greuter, 2004). Through these functions, technology within the FDD loop operationalises the human-centric vision of Industry 5.0, by embedding sustainability and adaptability into organizational practice while integrating productivity, well-being, and long-term development progress.

4 Organizational and Policy Implications in the Context of Industry 5.0

The introduction of Industry 5.0 in practise requires not only technological innovations, but also organisational and political changes. Successful implementation of the FDD loop depends on moving from control-orientated management to adaptive, collaborative leadership. At the same time, supportive policies at local, national, and EU level are needed to embed ethical safeguards, enable local implementation, and ensure inclusive access to Industry 5.0 practises. Effective governance requires participation at multiple levels: at the organisational level (ethics committees with worker representatives), at the regional/local level (alignment with local cultural norms and development priorities) and at the EU level (policy frameworks that incentivise people-centred, ethical HDT adoption). Such participatory oversight aligns with the emphasis on subsidiarity in Industry 5.0, which ensures that decisions are made at the most locally competent level while maintaining European alignment (Breque et al., 2021).

4.1 Organizational-Level Implications

At an organisational level, the transformation to Industry 5.0 requires new forms of leadership and personnel management. Managers must act as adaptive facilitators of the

co-evolution of people and technology, cultivating trust, transparency, and co-creation rather than exercising hierarchical control (Torbert & Associates, 2004). Human Resources (HR) needs to integrate JD-R diagnostics into surveys, incorporate developmental feedback, and create conditions for job crafting. HR should also adopt the logic of deliberately developmental organisations (Kegan et al., 2016), where vertical growth is treated as a key organisational outcome. Learning systems should include reflective practises, mentoring, and peer dialogues to ensure that vertical development is encouraged in everyday work. Organizational policies must explicitly ensure the ethical use of HDTs, to prevent surveillance or misuse, while ensuring transparency and employee participation in the design of adaptive interventions.

Exemplar Case: Regional SME Manufacturing Cluster

Small and medium-sized enterprises (SMEs) form the backbone of European manufacturing, and often lack the resources for sophisticated HR systems in countries such as Slovenia, Italy and Germany, but are central to the adoption of Industry 5.0 at a local level (Mihajlović, 2022).

Application of the FDD loop:

- **Field mapping**: interviews with managers and workers reveal restraining forces such as unpredictable spikes in demand, physical fatigue, skills gaps (in digital literacy), limited financial and human resources for large-scale change, and driving forces such as community identity and cohesion, pride in craftsmanship, flexibility in experimenting with new tools.
- **Development profiles:** Many workers operate from a socialized mind, valuing team norms and external guidance. Others (especially younger engineers) show signs of self-authoring, prioritizing autonomy.
- **JD-R diagnosis:** They show high physical demands combined with moderate autonomy and limited structured feedback.
- **HDT integration:** Low-cost, wearable sensors could detect fatigue; HDTs would model and balance workload and provide adaptive assistance. For socialised workers, nudges emphasise collective responsibility ("Let's rotate tasks to help the team"); for self-authoring workers, nudges emphasise autonomy ("You can optimise your own cycle by taking a break now").

Such an assessment and corresponding measures can lead to less strain on the musculoskeletal system, a better perception of fairness, and greater work commitment. By aligning Lewin's forces, developmental tailoring, JD-R balancing and the use of modular HDT systems adapted to the local context, SMEs improve sustainability without high capital expenditure. The key lies in adapting technological interventions to the cultural norms and development profiles of the workforce.

4.2 Municipal and Regional Policy Implications

Local authorities act both as employers and as political mediators. They can lead by example by embedding HDTs in their own administrations, and demonstrating how technology supports wellbeing and resilience. Local governments also play a catalytic role in supporting SMEs by providing subsidies, tax incentives, or grants for human-centred technologies. Regional innovation centres can coordinate pilot projects, linking academia, SMEs, and public administrations to jointly develop scalable Industry 5.0 solutions, fostering trust, transparency, and inclusivity.

Exemplar Case: Municipal Administration

Municipal administrations in Europe are facing increasing pressure to digitalise, while at the same time having to ensure equitable citizen services. Employees are confronted with administrative overload, changing (fragmented) digital platforms, and political responsibility stress.

Application of the FDD Loop:

- **Field mapping:** driving forces include commitment to public service, existing participatory administrative traditions, and pressure to modernise digital services for citizens; restraining forces include bureaucratic burden and digital fragmentation, and high cognitive demands on staff due to policy complexity.
- **Development profiles**: Staff are diverse — some with socialised orientations (following policy scripts, structured digital training modules), others with self-authoring capacities (dealing with ambiguity through adaptive planning).
- **JD-R diagnosis:** High cognitive demands (digital tools, regulations) combined with insufficient resources (clarity, training).
- **HDT integration:** A municipal pilot uses HDTs to monitor the switch between digital tasks and workload. When overload thresholds are detected, employees receive adaptive interventions: The use of tutorials for those who prefer structure, or prompts to redesign systems for those who prefer autonomy. Collective framework are used for retraining (“Progressing together as a community.”).

The measures would lead to a lower error rate, higher employee satisfaction (who feel more supported and autonomous), and more efficient service delivery. As HDTs support the development framework, employees gradually move to more complex meaning-making through resource-rich stimulation.

Municipalities are often early adopters of participatory governance models. Integrating Industry 5.0 principles is not only about efficiency, but also about building public trust and transparency. A municipality that exemplifies people-centric practises can set a precedent for local businesses and community organisations.

4.3 National Policy Implications

At national level, the principles of Industry 5.0 must be integrated into labour, education, and innovation strategies. Key mechanisms include: (1) national funding programmes that enable SMEs and public organisations to adopt HDT and adaptive learning systems, (2) regulatory frameworks that protect workers from technostress and algorithmic intrusion while ensuring the right to continuous learning, and (3) reforms that embed Industry 5.0 principles into vocational education and training curricula, with a focus on digital literacy, resilience, and vertical development.

Exemplar Case: Community Reskilling Initiative

European rural and peri-urban regions often experience demographic changes that require retraining initiatives to prepare workers for the tasks of Industry 5.0 (Breque et al., 2021).

Application of the FDD Loop:

- **Field mapping:** Restraining forces include low digital literacy, economic uncertainty and scepticism towards new technologies. Drivers include a strong local identity and a willingness to learn when the relevance is clear.
- **Development profiles:** Some operate at socialized stage (seeking community support), others at the self-authoring stage.
- **JD-R diagnosis**: High demands (learning curve, uncertainty), low resources (training, digital access).
- **HDT integration:** HDTs are integrated into the community training programmes, adapting the digital learning tasks to the individual's pace and level of development. For socialized learners, messages emphasise collective progress (“Your peers are making great progress, join in!”). For advanced learners, the messages emphasise individual mastery and contribution to local innovation.

Outcomes include improved training completion rates, greater confidence in using new digital tools, strengthening community resilience, and enabling smoother adoption of Industry 5.0 practises. The FDD loop here directly supports regional cohesion, resilience and inclusive growth, by ensuring that vulnerable groups can also actively participate in the digital transition and fostering intergenerational solidarity.

From these cases, several cross-cutting insights can be identified. Scalability is facilitated by modularity, as HDT architectures can be configured along a continuum ranging from simple wearable applications in small and medium-sized enterprises to comprehensive digital ecosystems in the public sector. Furthermore, the effectiveness of such interventions depends on their cultural and developmental appropriateness, which requires sensitivity to both local value systems and the developmental sequence of

individuals to ensure contextual relevance and user acceptance. Finally, the FDD loop proves to be a resilience-building mechanism by simultaneously strengthening individual capabilities to cope with job demands and organisational capabilities to adapt to changing environmental conditions.

5 Ethical and regulatory considerations in the use of human digital twins in the FDD Loop

While HDTs and the broader FDD loop create opportunities to balance industrial performance with human well-being, they also raise profound ethical and regulatory challenges. Ethical safeguards are not optional add-ons, but essential elements of responsible, human-centred Industry 5.0 innovation (Breque et al., 2021).

Data Privacy and Ownership

HDTs rely on highly sensitive personal data, including physiological signals, emotional states, behavioural patterns, and developmental assessments. The misuse of such data — whether for surveillance, punitive practices, or commercial exploitation — poses a significant risk to the dignity and trust of workers. Effective governance must therefore ensure data ownership (workers retain full ownership of their HDT data), informed consent (explicit, informed consent with clear boundaries), regulatory alignment (in line with the General Data Protection Regulation and the forthcoming EU Artificial Intelligence Act). Equally important is transparency about how data is collected, modelled and used. Without transparency, employees may perceive HDTs as surveillance tools rather than development supports, which undermines trust and engagement.

Autonomy and Non-Manipulation

Adaptive interventions must respect the autonomy of employees and avoid manipulative interventions. Labelling a workload adjustment as a 'team contribution' may be developmentally appropriate for employees at earlier stages of meaning-making, but if applied coercively, it risks reinforcing dependency rather than fostering growth. Ethical deployment requires a participatory design, in which employees actively shape the interventions that affect them. This ensures that the technology serves as a framework for development and well-being rather than a mechanism of subtle control.

Fairness and Non-Discrimination

Developmental assessments harbour the risk of being interpreted as fixed labels. Misuse could reinforce exclusion, stigmatisation or stratification within organisations. Instead, development profiles should be used to tailor learning opportunities, align resources, and provide supportive feedback. Fairness also requires equal access across organisational

contexts. The benefits of HDTs should not be limited to large, well-resourced companies; SMEs, municipalities, and community organisations must also have access to people-centred technologies to prevent widening social and economic inequalities.

Participatory Oversight and Governance

To be consistent with the principles of Industry 5.0, governance frameworks must emphasise participatory oversight. Workers, managers, policy makers and civil society actors should jointly create oversight bodies that ensure ethical accountability, transparent communication, and continuous improvement of HDT applications. Participatory councils and ethical review bodies can ensure that implementation considers both collective and individual well-being.

6 Conclusion

Industry 5.0 is not just a continuation of the digital transformation, but a systemic reorientation that integrates technological, psychological, and ethical dimensions into industrial practise. The proposed Field Development Demands (FDD) loop shows how Lewin's field theory, the Job Demands–Resources model, and the theory of vertical development can be operationalised through Human Digital Twins (HDTs) to create adaptive, human-centric workplaces.

The framework shows that behaviour in organisations is dynamic, and arises from the continuous interaction between person and environment, moderated by developmental capability and balanced by resources and demands. Technology, when used ethically, acts as both a field regulator and a development catalyst, ensuring that industrial systems evolve in line with human needs rather than against them.

Empirical examples at the local level show that the principles of Industry 5.0 can be effectively implemented even in resource-constrained environments, as long as the measures are developmentally tailored and culturally sensitive. This emphasises the flexibility and inclusivity, of Industry 5.0 and its potential to scale resilience, sustainability, and empowerment in different European contexts.

Policy implications emphasise the importance of multi-level governance. Organisations need to adopt participatory and developmental approaches; municipalities should act as laboratories for people-centred governance; national frameworks need to embed Industry 5.0 into education, work and innovation systems; and EU-level initiatives such as Horizon Europe and the Artificial Intelligence Act need to ensure ethical alignment and scalability.

Methodologically, future research needs to address gaps in validity, scalability, cross-cultural adaptation, and longitudinal impact. By combining quantitative JD-R measures,

developmental diagnostics, HDT-based sensing, and qualitative insights, researchers can empirically validate and refine the FDD loop as a scientifically robust paradigm.

Looking to the future, Europe's leadership in Industry 5.0 will rest on its ability to harmonise theory, practise, and governance in the service of human well-being. Industry 5.0 offers the opportunity to reconceptualise work as an area of productivity and personal growth, moving from efficiency to resilience, from horizontal training to vertical development, and from standardised designs to adaptive systems. If realised, this transformation has the potential to create not only smarter industries, but also stronger and more resilient communities across Europe.

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