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A taxonomy of innovation spaces from the innovation networks lens

Jose Montes[1*], Aglaya Batz[1] and Lizeth Fernanda Serrano Cárdenas[1]

*Correspondence: joseo.montes@urosario.edu.co

[1] School of Management and Business, Innovation Center, Universidad del Rosario, Autopista Norte Con Calle 200, Bogota, Colombia

Abstract

Collaborative innovation addresses intricate, multifaceted problems of a systemic nature involving a multitude of actors with diverse and often unknown expectations. To facilitate this collaboration, innovation spaces—such as Makerspaces, Hackerspaces, Fablabs, among others—have emerged as arenas where networks of actors interconnect and solidify. Understanding the diverse nature of these innovation spaces poses a challenge, particularly in distinguishing their specific characteristics and assessing how each contributes to fostering innovative networks. This article aims to address the question: how can we classify innovation spaces based on the innovation networks they constitute? To tackle this query, we initially conducted an in-depth exploration of various innovation spaces through web content analysis, scrutinizing their individual value propositions. Subsequently, employing innovation network theory alongside domain analysis methodology, we proposed a taxonomy designed to classify the distinct types of innovation spaces under scrutiny. Our taxonomy reveals three types of spaces—learn-and-explore, partner-and impact, and transitory—as well as convergent and divergent spaces, showing the diversity and complexity of networks they constitute. The findings also show that while the majority of innovation spaces unite diverse actors to drive collaboration and innovation, many resulting networks have a medium level of formality and are project-centric. These networks tend to be synthetic in nature, seeking to apply existing knowledge, and represent exploration networks wherein the adaptability and diversity of initiatives foster learning, the acquisition of new knowledge, and the development of fresh capacities through interactions.

Keywords: Innovation spaces, Innovation networks, Taxonomy, Domain analysis, Collaboration

Introduction

Innovation today is increasingly a collaborative effort among diverse organizations rather than solely the endeavor of a single firm (Berchicci, 2013). This collaborative approach allows organizations to mitigate risks and gain cost-effective and expeditious access to a broader spectrum of knowledge and technologies, thereby enhancing their innovation capabilities (Chesbrough, 2003; Trott & Hartmann, 2009). The evolution toward collaborative innovation sparked considerable interest among scholars in the 1990s and has since intensified, particularly in the past decade (Bernela & Levy, 2015; Geldes et al., 2017), culminating in the emergence of innovation spaces.

In the present landscape, organizations and individuals face the imperative of devising substantial learning, involving an understanding of the interdependent interests of diverse actors engaged in both problem comprehension and solution development (Ooms & Piepenbrink, 2021). Within this dynamic, actors in the innovation ecosystem have turned to innovation spaces to facilitate open collaboration, manage risks inherent in complex solution development, cultivate capabilities, and streamline knowledge consolidation (Bogers & Zobel, 2017). Hence, over the past decade, various types of innovation spaces—Fablabs, Fablearn Labs, Hackerspaces, Idealabs, Innovation Centers, Innovation Labs, Makerspaces, Social Innovation Labs, Socialabs, STEAM Labs, Public Innovation Labs, Citizenlabs—have emerged, each grounded in collaborative, open, and networked approaches aimed at expediting knowledge aggregation and generation processes.

Innovation spaces, often physical but increasingly virtual, align with varied goals and may offer technological resources and guidance (Bloom & Faulkner, 2016) to foster innovations directed toward addressing societal issues or nurturing innovation capabilities. Innovation spaces amalgamate individuals, resources, funding, methodologies, approaches, and experiences conducive to the innovation process. They stand as pivotal components within the innovation ecosystem of cities and countries, bridging the creative potential of individuals, the innovation prowess of companies, and even the transformational challenges encountered by governments (Capdevila, 2013).

Yet, despite their relevance and the rise of these collaborative settings, some share common characteristics, while others exhibit distinct attributes that set them apart in terms of value generation methodologies. Consequently, there is a growing need for reference taxonomies that afford a comprehensive understanding of these spaces. Hence, this article embarks on an exploration, employing web content analysis and domain analysis of 111 globally located spaces, to address the question: *How can we classify innovation spaces based on the innovation networks they constitute?*

Comprehensive studies that analyze innovation spaces and conduct comparative assessments are notably sparse, often lacking empirical foundations. Aligning with Thoring et al. (2020), the current state of research on the distinctive traits of innovation and creative spaces remains in its nascent phase. While several studies have explored the characteristics of various innovation spaces like Social Innovation Labs, Fablabs, Makerspaces, Innovation Centers, and STEAM Labs, these investigations often focus on individual spaces separately (González et al., 2020; Narayanan, 2017). Van Holm (2014) highlights the division among researchers regarding whether diverse innovation spaces like Makerspaces, Hackerspaces, and Fablabs should be regarded as distinct entities or interchangeable, indicating a crucial need for clarification to drive research forward. Conversely, Guthrie (2014), through a case study, draws distinctions between Hackerspaces and Fablabs, revealing disparities in their community impact and ecosystem management. However, among the reviewed studies, only one (Morel et al., 2018) extends beyond examining solely Makerspaces, Hackerspaces, and Fablabs. In addition, Yang et al. (2016) compare Makerspaces, Hackerspaces, Fablabs, and Techshops but within a limited scope focused on China and the US, overlooking other types of spaces and other countries.

While previous research has made strides in crafting typological frameworks, many studies, including those mentioned earlier, have narrowly focused on specific types of innovation spaces like Hackerspaces, Fablabs, and Makerspaces, neglecting collaborative setups with a social emphasis—Social Innovation Spaces, Socialabs, Citizenlabs. In contrast, this research aims to introduce a taxonomy leveraging the theoretical perspective of innovation networks (Corsaro et al., 2012; Hagedoorn & Duysters, 2002). This taxonomy aims to differentiate a broader spectrum of innovation spaces, examining the temporal aspects within the network structures they engender, the configurations they adopt, and the knowledge domains to which these spaces cater.

This research holds the promise of offering contributions at both managerial and theoretical levels. On a managerial front, a more profound comprehension of these spaces' characteristics aids in discerning the fundamental components pivotal for achieving targeted innovation outcomes. While some similarities exist among innovation spaces, each harbors its unique value proposition and resource configuration, crucial for delivering innovation. Acquiring this nuanced understanding empowers managers to make informed choices and allocate resources effectively. Moreover, a comprehensive grasp of these spaces' characteristics and aims enables the adept management of a skillful blend encompassing skills, relationships, offerings, and activities. It empowers managers to curate an optimal combination of strategies conducive to sustainable operations and innovation.

In the theoretical realm, this paper enriches the discourse on creativity, innovation, technology management, and social innovation. By systematically documenting the initiatives implemented by innovation spaces to generate value, it paves the way for a rigorous and comprehensive compilation of these endeavors. Our findings reveal three types of clusters—*learn-and-explore*, *partner-and impact*, and *transitory*—that group most of the spaces, which has not been documented in extant literature. Furthermore, our empirical exploration navigates a path that intersects with, yet diverges from, previous literature on innovation spaces as facilitators of technology, innovation, and knowledge transfer. Our analysis meticulously examines these points of divergence and convergence, contributing to a deeper understanding of the nuanced dynamics within these environments for innovation; this research analyzes *convergent* and *divergent* spaces, showing the diversity and complexity of networks they constitute.

Theoretical framework

Collaboration, networks, and innovation spaces

Collaborative innovation is perceived as a strategy that integrates the expertise of both internal and external stakeholders within an organization, fostering continual learning through the exchange of ideas, knowledge, experiences, and opportunities (Ketchen et al., 2007). It emerges from interactions among diverse actors often belonging to various social or technological networks, and sectors (Håkansson & Olsen, 2012). A multitude of actors actively participate in the innovation processes, representing a fundamental aspect of collaborative innovation. This diverse participation forms the foundational basis of innovation networks, which are viewed as interconnected organizations nurturing, acquiring, and amalgamating the knowledge and skills necessary for envisioning and executing complex solutions (Corsaro et al., 2012). The significance of establishing robust networks for innovation has been emphasized by numerous authors who have scrutinized the mechanisms behind knowledge acquisition and creation (Hagedoorn & Duysters, 2002; Montes et al., 2023).

Within these networks, innovation materializes because of connections and the frequency of interactions facilitated by open and systemic processes (Chesbrough, 2003). Knowledge is acquired and generated from external sources, thereby fostering the creation of competitive advantages. Previous empirical research has demonstrated that firms not engaging in cooperation and knowledge exchange, whether formal or informal, gradually limit their knowledge base over time, ultimately reducing their capacity to innovate (Pittaway et al., 2004).

Networks serve as highly efficient mechanisms for accessing innovation-related knowledge (Powell, 1998). The primary advantages stemming from the consolidation of innovation networks include risk-sharing (Xie et al., 2016), accessing new technologies and knowledge and new markets, fostering interorganizational learning (Dyer & Nobeoka, 2000), expediting the development of innovative solutions, and sharing complementary capabilities (Hagedoorn & Duysters, 2002). These benefits have been supported by other authors who have investigated innovation spaces as means to expedite the innovation process from a collaborative perspective (e.g., Bloom & Faulkner, 2016; Morel et al., 2018). This explains the increasing proliferation of these spaces and the growing academic and practical interest in their examination (Johns & Hall, 2020).

In addition, innovation spaces, with their focus on collaborative potential, are examined through three distinct perspectives. Initially, scholars explore the layout and design of these spaces, highlighting that whether physical or virtual, they significantly foster creative processes and serve as fertile ground for potentially groundbreaking ideas to emerge (Bloom & Faulkner, 2016). While the physical setting of a laboratory may crucially support innovation, the emphasis often shifts toward innovative thinking and methodologies. While the physical layout and design of a laboratory play an instrumental role in nurturing innovation, fieldwork assumes equal importance, particularly in ensuring a human-centered approach (Auernhammer, 2020).

Second, innovation spaces are recognized as knowledge hubs—found in diverse settings including business environments (Fiore & Rosani, 2018), dynamic living laboratories fostering community development (Leminen et al., 2012), or as essential knowledge repositories within or near educational institutions (Youtie & Shapira, 2008). While each hub operates within its unique contextual framework, it typically encompasses essential components: a physical environment, necessary resources, and facilitation (Memon et al., 2018). Evers (2008) conceptualizes knowledge hubs as focal points for diverse knowledge communities and interests, with core activities centered around transferring knowledge among participants. In specific, in a university setting, a knowledge hub is described as an 'organization transcending boundaries, serving as a mediating entity for exchanging both implicit and explicit knowledge between academia and local business and financial communities' (Youtie & Shapira, 2008, p. 1188).

Third, collaboration and co-creation play pivotal roles within these innovation spaces. Information processing serves as the foundation for the evolution and structure of multifaceted social networks (Estrada & Gómez-Gardeñes, 2014). Knowledge generation, driven by interactive dialogs and exchanges, requires meaningful interactions tailored to each participant's experiences. This leads to the accumulation and expansion of a robust knowledge base (Dankulov et al., 2015). Within this dynamic, actors in the innovation ecosystem pivot toward collaboration and openness to navigate the complexities inherent in developing sophisticated solutions. This fosters capabilities and streamlines knowledge consolidation more efficiently (Bogers & Zobel, 2017). Previous research confirms that consolidating collaborative networks, fostering proximity and knowledge exchange, enhances the potential to refine innovation processes, resulting in superior outcomes for all involved parties.

While acknowledging the pivotal role of networked collaboration within innovation spaces, several scholars advocate for a deeper exploration to assess the efficacy of these spaces in driving innovation within collaborative frameworks (Caccamo, 2020). To comprehensively address this inquiry, the theoretical framework of innovation networks has been employed. This framework serves as a lens through which to examine how these spaces conceptualize and operationalize collaborative schemes aimed at fostering innovation.

The lens of innovation networks to examine innovation spaces

We employ the perspective of innovation networks to delve into the dynamic relationships that innovation spaces cultivate with their beneficiaries and users, thereby fostering innovation. We aim to recognize three key aspects: (1) the network's temporality, encompassing formal and informal networks; (2) the network's knowledge base, involving analytic and synthetic networks; and (3) the network's structure and performance, focusing on exploration and exploitation networks.

Network's temporality The examination of network temporality encompasses a nuanced exploration into the formal and informal structures that underpin innovation networks. Formal structures, guided by explicit management systems (Burns & Stalker, 2006), embody a strategic approach. Ojasalo (2004) posits that perceiving innovation networks as formal projects significantly streamlines the innovation process, enhancing its manageability and the probability of yielding innovative outputs. Contrastingly, informal networks thrive devoid of explicit management structures, organically evolving through collaborative interactions and knowledge exchanges among individuals (Cross & Parker, 2004).

However, while informal networks initially demonstrate strengths in fostering effective communication and mutual understanding among participants, they pose challenges over time. Research indicates that these networks might confront hurdles in sustained collaboration and result generation (Klerkx & Aarts, 2013). Van Aken and Weggeman (2000) emphasize the efficiency of informal networks in exploring innovation potential and nurturing creativity. Nevertheless, the delicate balance in managing these networks becomes evident, insufficient management effort risks underutilization of their potential and subsequent productivity shortcomings. Conversely, excessive managerial intervention threatens to erode their inherent informality, consequently stifling their creative and explorative potential (Van Aken & Weggeman, 2000).

Network's knowledge base: Within innovation spaces, a pivotal exploration revolves around the network's knowledge base, delving into the intricate dynamics of knowledge circulation among users and teams and the resultant knowledge fostered through these interactions. This inquiry critically appraises the discernment between science-based and engineering-based knowledge perspectives, which bifurcate into analytical (science-based) and synthetic (engineering-based) knowledge bases, a conceptual distinction elucidated in the works of Asheim et al. (2011) and Martin and Moodysson (2013).

Analytical knowledge, rooted in deductive reasoning, predominantly thrives in industrial settings that heavily rely on fundamental research paradigms (Liu et al., 2014). Industries such as bio-medical, chemical-pharmaceutical, and select sub-sectors within the vast information and communication technology (ICT) landscape lean significantly on this knowledge base. This structured approach emphasizes systematic reasoning and empirical evidence to derive innovative solutions.

This type of knowledge is characterized by its contribution to knowledge networks through a deductive process and its role in fostering research collaborations among firms, often facilitated by their R&D departments (Asheim et al., 2011). Within networks driven by this knowledge type, the emphasis often lies on cultivating radical innovations and codifying knowledge through patents and publications. Geographically, these networks seek partners based on their possessed knowledge rather than their location (Plum & Hassink, 2011).

In contrast, the synthetic knowledge base embodies an engineering-oriented learning process prevalent in industrial settings favoring inductive methodologies, leveraging the application of pre-existing knowledge frameworks (Grillitsch et al., 2017). This approach places a premium on practical application, harnessing existing knowledge structures to engineer inventive solutions and innovations (Plum & Hassink, 2011).

The knowledge creation process within these networks is characterized by inductive reasoning and problem-solving orientation (Asheim et al., 2011). These networks are established with a specific problem-solving intent, leading to incremental innovation outputs primarily derived from the amalgamation of existing knowledge. Knowledge within these networks is typically tacit, involving concrete know-how, craftsmanship, and practical skills, often co-created alongside customers and suppliers (Plum & Hassink, 2011). In terms of geographical dispersion, these networks are highly responsive to global networking but are inherently location-specific (Liu et al., 2014).

Network's structure and performance: The investigation of network structure and performance parameters within the domains of exploitation and exploration constitutes a nuanced exploration into the dimensions of Exploration, Experimentation, and Execution (Nambisan, 2009). This scrutiny aims to unravel the intricate interplay within networks fostering both exploitation and exploration, recognizing these as pivotal components fueling innovative processes.

Rooted in March's work (1991), the literature articulates a distinction between exploration and exploitation networks. Exploration networks serve as vessels for generating novel knowledge and competences, while exploitation networks pivot toward the efficient utilization of existing assets, encompassing tangible and intangible capabilities (Nooteboom, 2006). Consequently, it is suggested that exploration networks thrive within looser-knit structures and less-regulated environments, as those found in

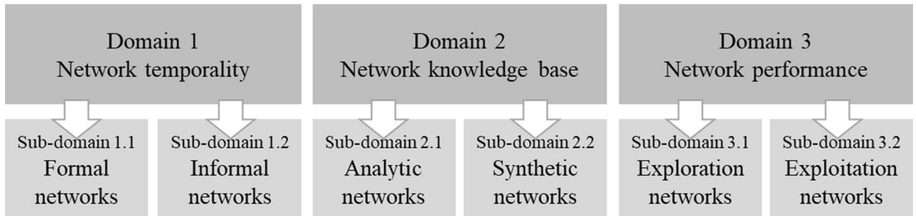

Fig. 1 Network classification: temporality, knowledge base, and performance

informal networks, fostering an atmosphere conducive to creativity and knowledge generation (Nooteboom, 2006). Given their pursuit of diverse knowledge, these networks tend to exhibit greater heterogeneity, leveraging diverse partners to enhance knowledge complementarity through diversified collaborations.

Conversely, exploitation networks channel efforts toward procuring benefits from innovation outcomes, with organizations striving to maximize gains from established technologies and products. Consequently, these networks, usually formal, concentrate on the practical manifestations of innovation, emphasizing product development, materialization, and commercialization (Naveh, 2005). They focus their learning endeavors on harnessing existing technological capabilities, refining current technologies, process enhancements, and cultivating economies of scale (Dittrich et al., 2007). Scholars suggests that collaboration among organizations within exploitation networks exhibits a positive correlation with efficiency, albeit with a simultaneous negative impact on innovation (Naveh, 2005).

These three classifications were established in the domains and in the sub-categories of the analysis of the information on the web page of the innovation spaces studied (Fig. 1).

Methods

To conduct this research, we employed a qualitative methodology comprising three distinct steps involving web content analysis (Elo et al., 2014) and domain analysis (Atkinson & Hap, 1996): (1) identification and selection, (2) data collection, and (3) domain analysis. Web content analysis enables the retrieval and exploration of readily available online information (Elo et al., 2014), while domain analysis facilitates an in-depth description and organization of innovation spaces into domains (Atkinson & Hap, 1996), forming a conceptual taxonomy that aids in their classification. The 111 selected spaces served as the units of analysis.

Identification and selection

The process of identifying innovation spaces involved sourcing information from online platforms and leveraging the expertise of the research team members. Initially, a total of 313 spaces were compiled in Microsoft Excel matrices. These matrices included essential details such as the space's name, country, website, social media accounts, and language (Annex 1[1]).

[1] https://shorturl.at/rzKZ5.

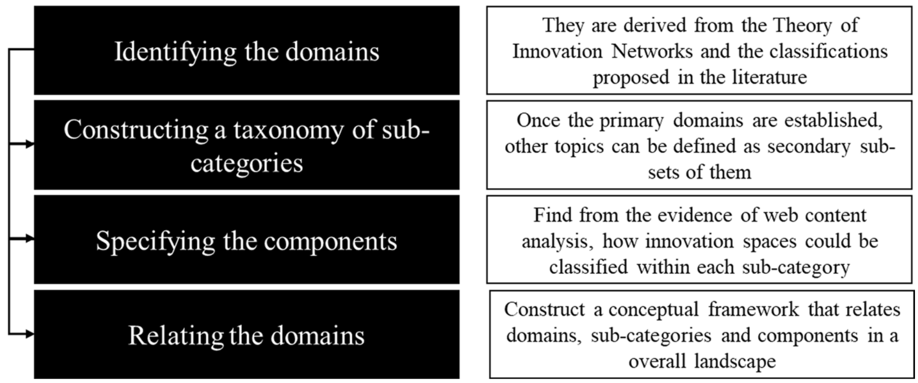

Fig. 2 Domain analysis

Following the identification phase, we employed criterion sampling (Patton, 2014) to select 111 spaces for further analysis (Annex 2[2]). Our selection criteria included spaces with updated websites, commercially active, regularly maintained social media accounts for triangulation purposes, and available information in English, Spanish, or Portuguese.

Data collection

After the selection process, we meticulously gathered pertinent details about the spaces' offerings, capabilities, and activities within an Excel matrix. Our information collection focused on various aspects, encompassing channels used to communicate with clients, core competencies, ways to maintain relationships with users/clients, customer segment, digital transformation initiatives, key activities and processes, key resources, mission, partner network, products and services, revenue streams, and value proposition. We collected this information whenever it was accessible.

Domain analysis

The domain analysis, depicted in Fig. 2, encompassed four distinct processes (Atkinson & Hap, 1996). Initially, we identified the domains rooted in the existing innovation networks theory present in literature (temporality, knowledge base, and performance). Subsequently, we crafted several sub-categories aimed at refining classification, capturing the intricate nuances inherent in the analyzed spaces (formal–informal, analytic–synthetic, exploration–exploitation). Next, leveraging online information, we categorized the innovation spaces within the specified domains and sub-categories. Last, we developed a taxonomy that interlinked the domains and sub-categories, integrating emergent typologies or relationships discerned from the data.

This domain analysis was conducted by a team of three researchers well-versed in the literature on innovation spaces and knowledgeable about the selected innovation spaces. To execute the analysis, each researcher was assigned 37 spaces randomly. Their task involved assigning appropriate domains and sub-categories to each space based on the collected information, subsequently justifying their selections during team debriefing

[2] https://shorturl.at/EKLMV.

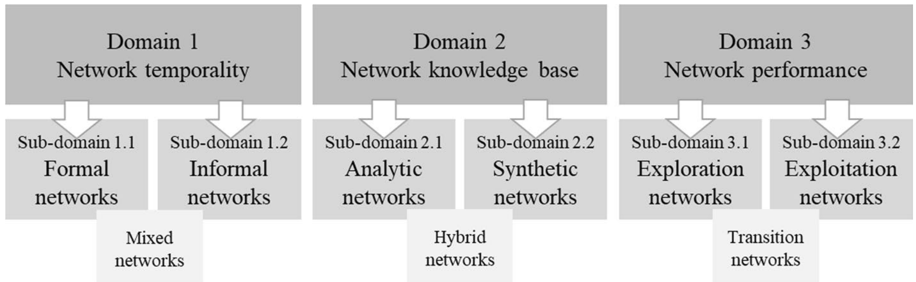

Fig. 3 Network classification with intermediary sub-domains

sessions. This process encouraged collaborative discussion and allowed for challenges to the initial classifications proposed by each researcher. The final classification was established upon agreement among all three researchers (Annex 3[3]).

Upon completion and validation of the classification process, we organized the findings into a 3D cube format, aiding in visualization and interpretation (Annex 4[4]).

During the data analysis phase, our research team opted to introduce intermediary sub-domains—mixed, hybrid, and transition—within each domain—temporality, knowledge base, and performance—to offer a more nuanced and accurate representation of the identified, selected, and analyzed spaces (depicted in Fig. 3). Spaces were classified as *'mixed'* when they exhibited characteristics of both formal and informal networks within the network temporality context. *'Hybrid'* designations were assigned to spaces showcasing elements of both analytic and synthetic networks in their knowledge base. *'Transition'* classification applied to spaces demonstrating traits of both exploration and exploitation networks concerning network performance.

Results

The temporality–knowledge–performance cube (TKP cube)

The *TKP Cube* revealed three prominent clusters encompassing more than half of the examined spaces (Fig. 4).[5]

a. *Learn-and-explore cluster* It is the largest cluster (highlighted in blue), and stands out for its amalgamation of spaces operating within networks showcasing mixed temporality, a synthetic knowledge base, and exploration-oriented performance. These spaces foster user engagement through memberships and informal collaboration with partners. They prioritize collaboration through practical projects, problem-solving, and engineering initiatives, fostering an environment conducive to continuous experimentation, trial and error, and experiential learning. Notably, this cluster comprises 25 spaces, predominantly Makerspaces (11), Hackerspaces (5), and Fablearn Labs (3), alongside Fablabs (2), Idealabs (2), and STEAM Labs (2). These spaces col-

[3] https://shorturl.at/wCPY3.

[4] https://shorturl.at/aAIX7.

[5] For an easy exploration of the cube and interpretation of the results please review the 3D version of it (TKP Cube): https://shorturl.at/aAIX7.

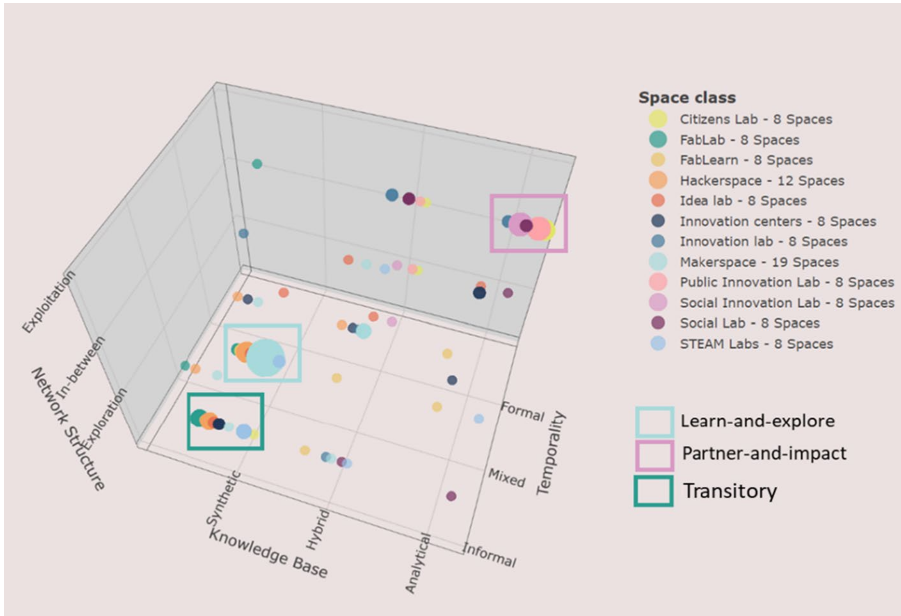

Fig. 4 TKP Cube: taxonomy of clusters of innovation spaces (smaller clusters form groups of 3 to 6 spaces. This is the case of the clusters that integrate spaces that conform: formal, hybrid and exploitation networks (6 spaces); mixed, hybrid and transition networks (6); informal, hybrid and exploration networks (5); mixed, hybrid and exploitation networks (3); formal, hybrid and transition networks (3), mixed, synthetic, and transition networks (3); and informal, synthetic and transition networks (3). Groups of less than 3 spaces were not counted as clusters due to the negligible number of spaces)

lectively embrace a 'maker' ethos, emphasizing do-it-yourself activities, ideation, and prototyping.

b. *Partner-and-impact cluster* It is the second-largest cluster (highlighted in purple in Fig. 4), and primarily encompasses spaces operating within formal, analytical, and exploitation-oriented networks. These spaces prioritize the establishment of enduring, formal partnerships with beneficiaries and collaborators. Some spaces in this cluster also focus on codifying knowledge derived from their exploration of various phenomena and interactions with specific populations, often through regulatory guidelines and policy briefs. In addition, these spaces strive to implement and scale initiatives with economic, environmental, and social impact. Comprising 21 spaces, this cluster is chiefly composed of Public Innovation Labs (6), Social Innovation Labs (6), and Citizenlabs (5). These spaces commonly forge formal contractual ties with funding entities, leveraging innovative programs to address diverse social and economic challenges and directly impact their targeted spheres, such as poverty alleviation, crime reduction, and literacy initiatives. This cluster also encompasses Sociallabs (2) and Innovation Labs (2), albeit in smaller numbers.

c. *Transitory cluster* It comprises spaces characterized by informal, synthetic, and exploration-driven networks (highlighted in green in Fig. 4). Within this cluster, there is a prevalence of short-term and standalone initiatives, often conducted independently of larger programs, contracts, or memberships. These initiatives, like courses, conferences, and volunteering activities, serve as predominant activities within this cluster. Like the *learn-and-explore cluster*, this group emphasizes learning through

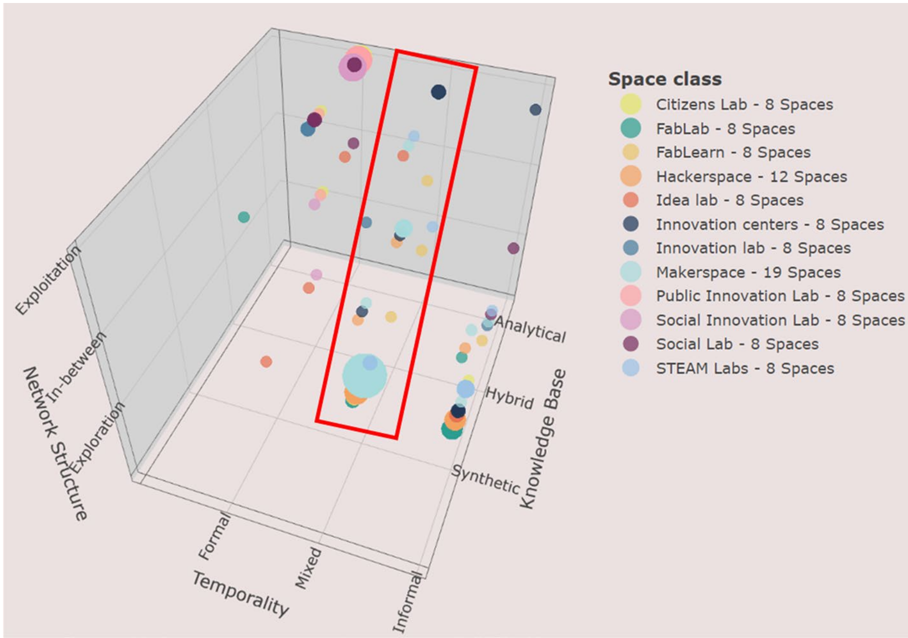

Fig. 5 Network temporality

practical application, exploration, and experimentation. However, due to the absence of formal structures, the initiatives undertaken by the transitory cluster are generally more transient, with narrower scale and scope. This cluster encompasses 17 spaces, predominantly consisting of Fablabs (4), Hackerspaces (4), and STEAM Labs (3). In addition, it includes Idealabs (2), Fablearn Labs (1), an Innovation Center (1), a Makerspace (1), and a Citizenlab (1), often operating on a pay-per-use model (e.g., machine and space rentals, short DIY workshops, and conference hosting).

Temporality

The results demonstrate that *nearly half of the spaces fall under networks characterized by mixed temporality* (Fig. 5). Despite lacking long-term formal contractual bonds with users, these spaces establish memberships that cultivate a connection between the space and its users. Predominantly, Makerspaces, Fablearn Labs, and Hackerspaces fall into this category. This alignment is not surprising, given that many members and users opt for pay-per-use or subscription-based access to tools and workshops, maintaining an informal relationship without formal contracts (Zheng et al., 2022).

Approximately a third of the spaces operate within a formal temporality, seeking to establish enduring, formal alliances through contractual agreements. These agreements ensure a management structure, typically formed with a clear goal in mind (Allen et al., 2007). This classification encompasses the majority of Public Innovation Labs, Social Innovation Labs, Socialabs, and Citizenlabs. The need for a long-term approach toward addressing public and social issues often drives these spaces, often necessitating formal contracts, particularly for those receiving public funding and grants.

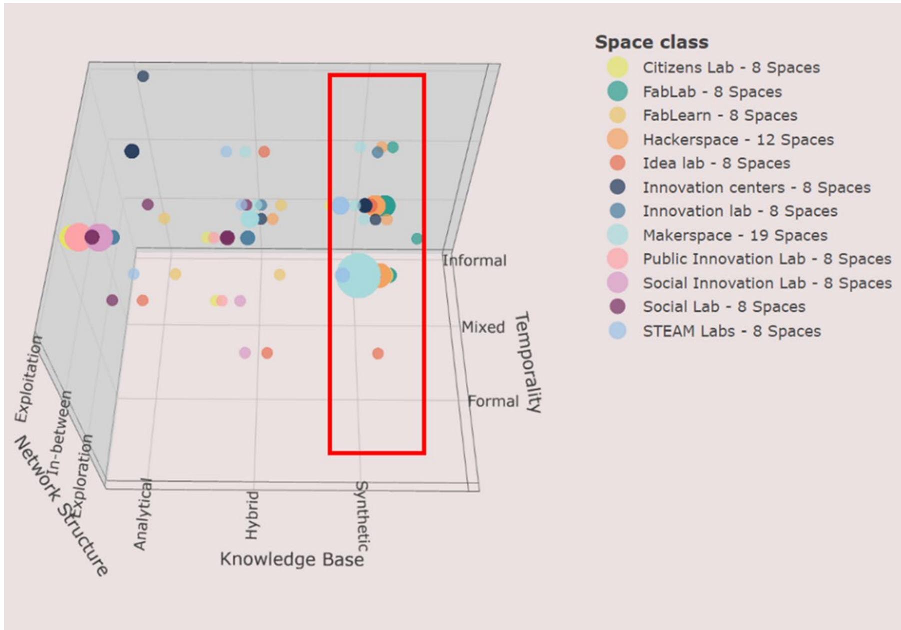

Fig. 6 Network knowledge base

In contrast, only *a quarter of the spaces operate within an informal network*, where relationships are often tied to specific events or activities without a focus on fostering long-term strategic partnerships. They may also bridge disparate groups, and in the long run these relationships may unveil critical disconnections between businesses and individuals (Cross & Parker, 2004). This category mostly encompasses Fablabs. The discovery that only a quarter of spaces fall under the informal temporality was unexpected, considering the inherently informal nature of many these spaces. Initially, we anticipated a higher proportion, likely exceeding 50%.

Knowledge base

The analysis highlights that half of the examined spaces operate within *a synthetic knowledge network*, focusing on practical know-how and the application of knowledge to address specific problems (Fig. 6). Most Makerspaces, Hackerspaces, and Fablabs align with this type of network, engaging in ideation, prototype development, and hackathons. These spaces emphasize learning through hands-on experiences, a distinctive feature of synthetic networks (Plum & Hassink, 2011).

Approximately a quarter of the spaces operate within an *analytic knowledge network*, concentrating on generating explicit knowledge in forms such as patents, industrial designs, scientific publications, and codified knowledge like policies and regulations. Predominantly, Social Innovation Labs and Public Innovation Labs align with this network, actively contributing to policy development and regulations based on their in-depth understanding of the social contexts they engage with.

Furthermore, a quarter of the spaces constitute a hybrid knowledge base, involved in generating designs, prototypes, toolkits, and audiovisual content. These spaces might be transitioning from a synthetic to an analytic network. Innovation Labs largely fall

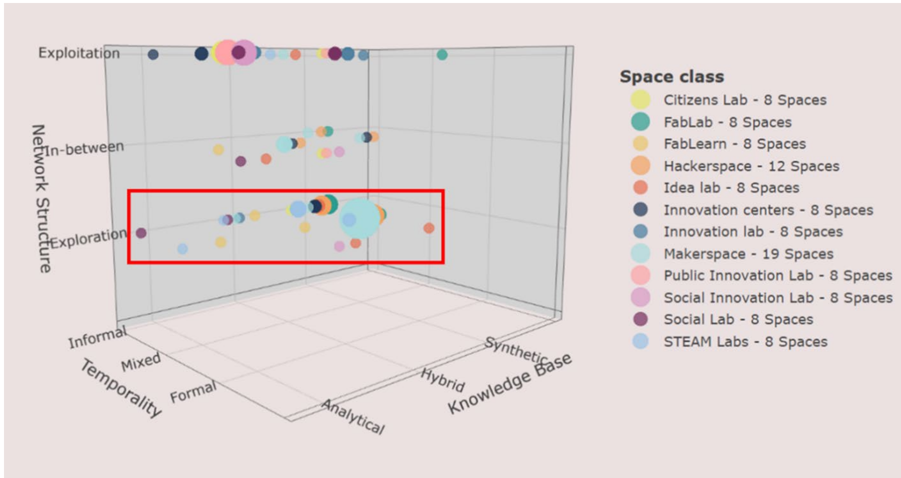

Fig. 7 Network structure

into this category due to their diverse activities and the varied intellectual property agreements established with users and customers. Unlike the synthetic and analytic knowledge bases, the hybrid category, except for Innovation Centers, does not exhibit concentrated groups of specific space types; there are only a few spaces of each type found in this category.

Network performance

More than half of these innovation spaces demonstrate an inclination toward exploration networks, as highlighted in Fig. 7. These networks embody an ethos of experimentation with unconventional methods, processes, and tools to ignite creative endeavors and instigate new projects (Bogers & Zobel, 2017). Among those prominently falling into this category are Fablabs, Fablearn Labs, Hackerspaces, Idealabs, Makerspaces, and STEAM Labs (Narayanan, 2017). This alignment mirrors their inherent ethos of exploration, where the primary focus lies in testing novel ideas, engaging in project experimentation, and fostering learning through a trial-and-error approach, free from immediate market pressures (Hasti & Amo-Filva, 2023).

On the other hand, about a third of these spaces are situated within exploitation networks, directing their primary emphasis toward market-centric approaches aimed at deriving profits from the innovation process (Nooteboom, 2006; Johns & Hall, 2020). Public Innovation Labs, Social Innovation Labs, and Citizenlabs are predominantly associated with this network (Hassan, 2014). Their focus centers on scaling new businesses, commercializing innovations, or integrating these innovations into diverse products, services, processes, and institutions (Morel et al., 2018). Notably, these spaces are pivotal in devising tangible solutions to various social, environmental, or economic challenges faced by their stakeholders (González et al., 2020).

Last, a minority of spaces fit within the transition network. These spaces possess the capacity to develop concepts, business models, and minimum viable products, and to conduct market studies to gauge the acceptance of specific products or services (Corsaro et al., 2012). However, their primary forte does not lie in commercialization, scalability,

Table 1 Differences between convergent and divergent spaces

Convergent	Divergent
Concentrated in specific TKP Cube regions, indicating a consistent pattern in partner interaction, outcome generation, and relationship establishment across the same type of space	Scattered across the TKP Cube without a defined pattern, indicating that within the same kind of spaces there is not a specific focus on the types of outcomes and partnerships they establish
Typically exhibit a formal temporality, hence, establish long lasting and explicit contractual relationships with partners	Primarily focus on a mixed temporality, therefore, do not develop long-term formal contractual bonds with users, but establish membership schemes to cultivate interactions with them
Emphasize an analytic knowledge base that favors science-based and codified knowledge	Tend to center on a synthetic knowledge base rooted in engineering-based and tacit knowledge
Predominantly operate with an exploitation network performance generally seeking to obtain and maximize benefits from the innovation endeavors	Primarily focus on an exploration network that tends to foster creativity and examine new ideas

or immediate market impact, which form the core of the exploitation networks (Nooteboom, 2008). As depicted in Fig. 7, there is no distinct clustering of a particular type of space within the transition network; instead, only a few spaces of each type fall into this segment. This observation could be attributed to the distinct missions of these spaces. Those primarily focused on profitability and market success (exploitation) or those engaged in technological experimentation (exploration) might risk diluting their value proposition and mission by attempting to encompass both aspects, potentially leading to inefficient resource allocation (Hagedoorn & Duysters, 2002).

Convergent and divergent spaces

The TKP Cube delineates two distinct types of spaces categorized by their spatial dispersion tendencies: convergent and divergent. Convergent spaces cluster within similar regions of the cube, exhibiting evident patterns in the temporality, knowledge base, and performance of their networks. On the other hand, divergent spaces scatter across the cube without a defined structure concerning knowledge base, network structure, and temporality. This distinction between convergent and divergent spaces is important because it helps us distinguish the types of spaces that are more consolidated and consistent, from those that are less structured—with regard to the innovation networks they constitute. In addition, this differentiation is key to understand the levels of fundamental similarities and variations between the spaces within the same type, which may be an indicator of the maturity level—as a group—of the distinct environments for innovation (Table 1).

Convergent spaces

The results indicate that more than half of the Citizenlabs (5/8), Fablabs (4/8), Makerspaces (11/19), Public Innovation Labs (6/8), and Social Innovation Labs (6/8) are in a specific area of the TKP Cube. In general, these spaces tend to be placed in a particular region of the TKP Cube, showing a consistent pattern in partner interaction, outcome generation, and relationship establishment. More than half of convergent spaces exhibit a formal temporality, analytic knowledge base and exploitation network performance.

Citizenlabs serve as innovative spaces fostering collective intelligence (Hallin & Lipka, 2023), civic engagement, and participatory processes aimed at overarching and inclusive goals (Pascale & Resina, 2020). These goals can be as broad as the SDGs (Pascale & Resina, 2020), public policy design and implementation(Hallin & Lipka, 2023), and extend to citizen involvement in scientific exploration (Witt et al., 2023).

Within the TKP Cube, 63% of Citizenlabs align at the crossroads of analytic knowledge, formal temporality, and an exploitation-oriented network structure. Take, for instance, Citilab in Barcelona, Spain, dedicated to cultivating citizen innovation for the propagation of a Knowledge Society. Its approach integrates design thinking, computational strategies, and user-centered co-creation methods, placing citizens at the core of a collaborative, integrative process aimed at addressing multifaceted social and business challenges.

Fablabs are defined as accessible, community-centered spaces or labs, often small in scale, where design and production intersect through the utilization of 3D modeling software and various manufacturing techniques (Galuppo et al., 2019, p. 2). Across the Fablabs landscape, all align within a synthetic knowledge network, with 63% operating in a mixed temporality and 50% structured around an exploration-centric network.

In essence, around half of the Fablabs, situated within the TKP Cube, converge at the junction of a synthetic knowledge base, an informal temporality, and an exploration-oriented network structure. Consequently, their focus primarily revolves around practical knowledge application, often fostering relationships through memberships, while placing substantial emphasis on hands-on experimentation. Machines' Room, for example, located in London, facilitates collaborations among engineers, artists, and designers to explore inventive projects using digital manufacturing technologies. Their emphasis leans toward exploration rather than the scaling of business models or the commercial launch of products.

Makerspaces are characterized as communal spaces that foster interaction, idea exchange, and collaborative projects within technology, science, and arts (Halbinger, 2018, p. 2028). This ecosystem boasts a 74% inclination toward a synthetic knowledge base, 84% adoption of mixed temporalities, and 68% alignment with an exploration-centric network. Predominantly, a majority (56%) of these spaces cluster within the TKP Cube, primarily intersecting at the confluence of a synthetic knowledge base, mixed temporality, and exploration network structure, like Fablabs and certain Hackespaces.

However, diverging from Fablabs, Makerspaces typically conform to mixed temporalities due to their formal ties with parent institutions like universities and innovation centers, along with their adherence to the standards and values proposed by the Maker Network. For instance, The Maker's Space, situated in Raleigh, functions as a shared workshop and artisan community providing residency, memberships, and education in various crafts. This setup encourages members to explore unfamiliar machines and techniques, develop fresh skills, and foster a culture of creativity and innovation.

While the exploration aligns with Harbinger's (2018, p. 2028) definition of Makerspaces as open-access communities for collaboration in technology, science, and arts, our findings suggest a more pronounced focus on design, engineering, and manufacturing. There appears to be less emphasis on 'science' projects in these spaces, which tend to center more on the creative aspects of design and production.

Public Innovation Labs conceptually represent experimental spaces integrating co-creation methodologies to drive public innovation and social transformation (Zurbriggen

& Lago, 2019). These labs are pivotal in generating public value (Greve & Ysa, 2023) and often act as catalysts for inducing change in public management practices.

Our findings underscore that 75% of Public Innovation Labs align at the convergence of an analytic knowledge base, formal temporality, and exploitation network. These spaces excel in systematically documenting and producing knowledge regarding the impacts of their interventions. They maintain enduring partnerships with governmental agencies to secure funding and logistical support, enabling the design and implementation of large-scale, viable solutions.

For instance, consider the Public Policy Lab, a non-profit organization deeply embedded in formal collaborations with the NYC Mayor's Office. Functioning at the intersection of human-centered design and public policy, this lab addresses the needs of marginalized communities, particularly those facing financial hardships or at-risk situations.

Social Innovation Labs represent spaces geared toward fostering intricate inter-organizational collaborations aimed at addressing multifaceted challenges. These labs exhibit systemic, experimental, and socially oriented characteristics, adapting methodologies from collaboration theory literature to the innovation context (Marcelloni, 2023).

Our analysis aligns with Public Innovation Labs, indicating that 75% of Social Innovation Labs congregate at the crossroads of an analytic knowledge base, formal temporality, and exploitation network. Take, for instance, El Laboratorio de Innovación Social (LIS) in Medellin, Colombia. This lab engages in consulting processes and operates within the support framework of an academic institution, bolstered by two research groups that enrich its investigative endeavors. LIS not only offers advisory and consulting services but also prioritizes aiding users in diffusing and scaling social solutions.

Divergent spaces

The results show that an important number of Fablearn Labs (5/8), Hackerspaces (7/12), Idealabs (4/8), Innovation Labs (4/8), and in a relatively lesser extent, Innovation Centers (3/8), Social Labs (3/7), and STEAM Labs (3/8) are scattered across the TKP Cube. Divergent spaces are dispersed across the TKP Cube without a specific pattern, indicating that within the same kind of spaces there is not a particular focus on the types of outcomes and partnerships they stablish. Divergent spaces generally exhibit a medium temporality, center on a synthetic knowledge base, and primarily focus on an exploration network.

The aim of *Fablearn Labs* centers on didactic education (Gomes, 2016). Predominantly, 86% of these labs are part of an exploration network, with 75% reflecting a mixed temporality and 50% associated with a synthetic knowledge base. However, apart from the minority that converges at the intersection of mixed, synthetic, and exploration points, Fablearn Labs do not exhibit a specific concentration within the TKP Cube; instead, they display a scattered distribution.

These labs, on analysis, do not typically establish enduring contractual ties with users. Instead, they maintain informal connections through memberships, focusing their resources on learning, technological experimentation, and methodological exploration. Emphasizing tacit knowledge, learning-by-doing, and problem-solving, spaces like Remake Learning serve as prime examples. Operating as an open group, Remake Learning prioritizes informal knowledge exchange and idea sharing. While it adheres to network values, its core focus remains on learning, idea dissemination, and best practices rather than scaling or commercializing innovations.

The essence of *Hackerspaces* lies in being community environments dedicated to open-source hardware and software development, providing access to otherwise expensive equipment (Groenendyk & Gallant, 2013, p. 34). A significant majority, accounting for 92% of these spaces, aligns with a synthetic knowledge base. In addition, 75% adopt an exploration network structure, while 58% follow a mixed temporality. Despite their varied composition, the primary vortex encompasses these spaces, intersecting a mixed temporality, synthetic knowledge base, and exploration network structure, housing 5 out of 12 Hackerspaces.

This reveals the diverse nature of networks formed by these spaces, diverging from a strong convergence within a specific vortex, unlike Makerspaces where 56% coalesce within the synthetic, mixed, exploration vortex. However, the inference drawn highlights their collective emphasis on experimentation, tacit knowledge, and active engagement in hands-on projects and experiential learning. This resonance is akin to that observed in Makerspaces, Idealabs, Fablearn Labs, and Fablabs. Take NYC Resistors, situated in Boerum Hill, Brooklyn, for instance; this hacker collective convenes regularly for knowledge-sharing, collaborative project development, and community building in an inclusive and open environment. The communication channels primarily rely on informal mailing lists, indicative of the explorative and synthetic nature characterizing this Hackerspace.

Idealabs serve as conduits not only just for birthing fresh concepts but also for interlinking individuals from diverse backgrounds (Narayanan, 2017). An impressive 63% of Idealabs align with a synthetic knowledge base, while 75% operate within exploration networks. Temporally, these spaces are almost evenly distributed among formal, informal, and mixed temporalities. Like Fablabs and Fablearn Labs, Idealabs are deeply rooted in hands-on projects, leveraging tacit knowledge, tackling practical challenges, and centering their efforts on exploration and experimentation.

Interestingly, Idealabs lack a clustering trend within a particular point in the TKP Cube (Fig. 8); instead, they tend to orbit around the exploration line. For instance, both LPL Idea Lab and Idealab Studio exemplify this. Idealab Studio actively seeks substantial global challenges, brainstorming technological solutions, and parallelly testing numerous ideas—an emblem of exploration and synthetic networks. However, when a promising concept emerges, their approach transcends. They assemble a team, pivot it into an independent company, and facilitate its growth into a thriving business—a tendency more characteristic of exploitation networks.

Innovation Centers serve as pillars of support, offering essential aid—be it professional, financial, or infrastructure-related—to empower entrepreneurs in launching and expanding their enterprises (Fuzi, 2015). Surprisingly, while 50% of these centers converge within a mixed temporality, no distinct clustering pattern emerges concerning knowledge base and network performance. This category encompasses diverse entities such as the DHL Innovation Center, which emphasizes practical innovation experiences centered around logistics visions, trends, and solutions, and the Center

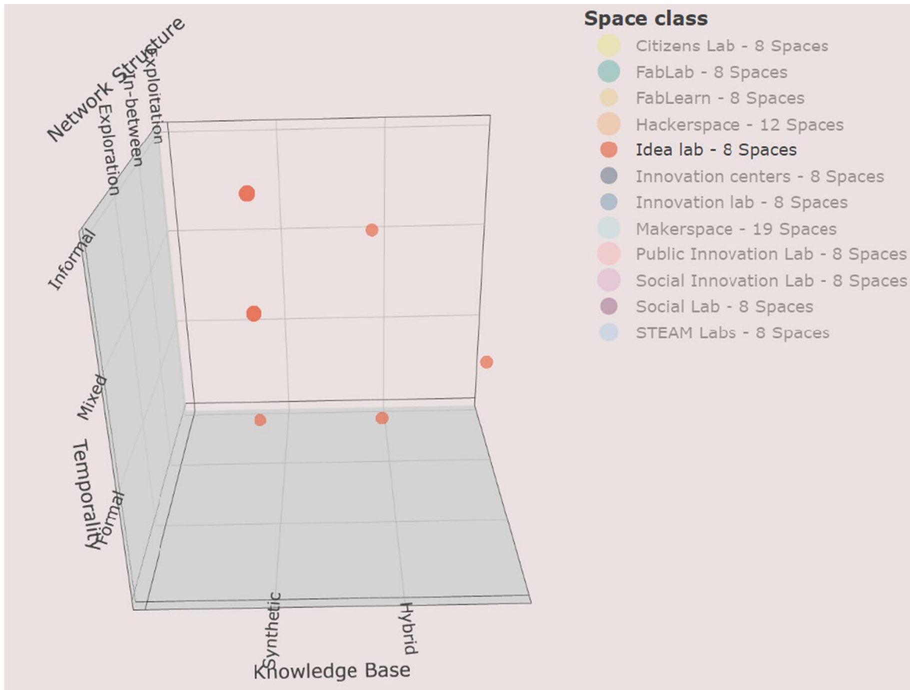

Fig. 8 Idealab

for Engineering Innovation and Design, focusing on nurturing ideas from conceptualization to realization in the real world.

An *Innovation Lab* epitomizes an organizational initiative and management model, cultivating an innovative environment—be it physical, virtual, or a hybrid blend—balancing space, infrastructure, and operational dimensions (Schiuma & Santarsiero, 2023, p. 14). These labs foster creative thinking, champion user-driven and open innovation methodologies, and actively engage stakeholders to envision and cultivate innovation opportunities, technology transformation, and novel business solutions (Schiuma & Santarsiero, 2023, p. 14). Interestingly, 63% of these labs are positioned along the axis of the hybrid knowledge base. One such example is the IDB Lab, affiliated with the Inter-American Development Bank (IDB) Group, devoted to piloting novel solutions addressing developmental challenges across Latin America and the Caribbean. Similarly, the Oracle Industries Innovation Lab simulates workspaces, showcasing the potential of transformative technologies like the Internet of Things (IoT), autonomous equipment, artificial intelligence, and machine learning, offering a glimpse into their evolving capabilities.

Socialabs represent experimental and participatory spaces geared toward addressing intricate societal challenges (Hassan, 2014). Among these, 63% align with a formal knowledge base but do not cluster specifically concerning temporality or network performance. For instance, the Social Value Lab operates as a multifaceted entity—a blend of consultancy, think tank, and incubator. Similarly, the UNICEF Lab's mission centers on identifying initiatives that yield substantial, sustainable, and scalable social impacts to expedite collective progress.

STEAM Labs serve as multidisciplinary spaces primarily centered around student engagement (Hasti & Amo-Filva, 2023). These environments focus on problem-solving by integrating diverse systems, technologies, and methodologies to address aspects of diversity affecting students, schools, and their social surroundings (Fonseca & Sanchez-Sepulveda, 2022). Although typically found in educational settings, STEAM Labs are not limited to schools; they function as multidimensional spaces emphasizing STEAM skill development and vocational exploration (Fonseca & Sanchez-Sepulveda, 2022). Results reveal a scattered distribution of STEAM Labs across the TKP Cube, with approximately 63% oriented toward a synthetic knowledge base. This inclination highlights a focus on practical, hands-on learning. For instance, Frost STEAM Labs—an educational technology company—aims to diversify STEAM industries by introducing elementary-aged students in underserved communities to various STEAM professions. The lab provides expertise through successful professionals from STEAM industries and education, assisting schools in establishing or enriching their STEAM programs.

Discussion

Theoretical implications and contribution

This paper contributes to the existing literature on innovation spaces and innovation networks in three significant ways. First, by delineating 12 distinct types of innovation spaces and clustering them into three primary groups, this study provides a more comprehensive taxonomy than previous research. The emergence of these clusters, particularly the “learn-and-explore,” “partner-and-impact,” and “transitory” clusters, mirrors the nuanced nature of these spaces in terms of temporality, knowledge base, and network performance (Thoring et al., 2020). The theoretical framework’s emphasis on temporality, knowledge base, and network structure is visibly reflected in these classifications, showing the relevance of these dimensions in understanding the diversity and functionalities of innovation spaces.

Second, the shift from categorizing spaces based on traditional business models to a framework rooted in temporality, knowledge base, and network performance aligns with the theoretical underpinnings emphasizing collaborative networks within these spaces. The classification based on temporality, knowledge base, and network performance mirrors the assertions made regarding the importance of these factors in shaping innovation networks and the exchange of knowledge and ideas within them (Corsaro et al., 2012; Nooteboom, 2006).

Moreover, the identification of convergent and divergent spaces within the TKP Cube underscores the varied organizational structures and characteristics present within different types of spaces. This notion corroborates the idea that spaces, despite being nominally categorized under a specific type, can exhibit substantial differences in their offerings, partnerships, and organizational structures. This resonates with the theoretical framework’s emphasis on understanding the diversity and heterogeneity within innovation networks, particularly in how these spaces organize their networks and engage with their ecosystems (Håkansson & Olsen, 2012).

The discovery of convergence among certain spaces, such as Citizenlabs and Fablabs, contrasted with the divergence observed in others like Idealabs or Innovation Centers, echoes the novel categorization introduced in this research. These distinct categories, previously unreported in literature, validate the importance of considering spatial dispersion as a factor contributing to the diversity and uniqueness among different innovation spaces.

Managerial and practical implications and contributions

This research provides invaluable insights for managers overseeing diverse innovation spaces. It proposes that most of these spaces are predominantly focused on exploration activities, fostering an environment conducive to creativity and generating substantial value for their users (Corsaro et al., 2012). However, an intriguing observation surfaces: the potential for these spaces to augment their impact by strategically integrating exploitation activities into their operations without compromising their core missions. Embracing exploitation initiatives could significantly bolster their financial sustainability, thereby broadening their horizons to offer novel products and services (Nooteboom, 2006).

The ability of these spaces to diversify their revenue streams through exploitation endeavors is paramount for their long-term viability and continued success. Indeed, the capability to generate sustainable income stands as a cornerstone for the enduring existence of these innovation spaces, ensuring their capacity to continually nurture innovation and serve their stakeholders (González et al., 2020). Engaging in exploitation activities not only acts as a buffer against potential financial challenges but also paves the way for the development and expansion of their offerings, enriching the value proposition they provide to their user base (Bogers & Zobel, 2017).

Moreover, our findings shed light on the temporal dynamics prevalent within these spaces. It becomes evident that many spaces operate within a medium temporality framework, strategically balancing formal and informal partnerships with diverse collaborators. This dual approach allows for the flexibility to experiment with different partnerships without incurring long-term commitments, providing a safety net in case of unfavorable outcomes. Simultaneously, it fosters the cultivation of enduring, meaningful relationships with partners who contribute shared value and synergies, ultimately enhancing the spaces' collaborative ecosystem (Håkansson & Olsen, 2012).

Furthermore, an intriguing trend emerges as most of these spaces tend to exhibit characteristics of divergence. This divergence manifests in their temporalities, knowledge bases, and network performances. While this diversification enriches the value proposition of each space, it also poses challenges by diluting the distinctive elements that set them apart. The varied configurations within each space type highlight the nuanced and heterogeneous nature of these innovation environments, contributing to a more diverse ecosystem but potentially blurring the distinctiveness that could differentiate them from other spaces (Thoring et al., 2020).

Limitations and further research

While this research sheds light on diverse innovation spaces, it is essential to acknowledge its limitations, paving the way for future investigations. First, the analysis, while comprehensive, could benefit from a larger sample size within each space type to enhance the robustness of the findings. A more extensive dataset would reinforce the credibility of the identified clusters and patterns, enhancing the generalizability of the outcomes to a broader spectrum of innovation spaces.

In addition, this study primarily relied on online information for data collection, a method utilized by many studies. However, future research could enrich these findings by employing complementary methodologies like interviews or surveys. Such triangulation methods could offer deeper insights into the distinct features and nuances of these spaces, providing a more holistic understanding beyond what online information alone can offer.

Moreover, the evolving landscape of innovation continually introduces new types of spaces. Although this study was exhaustive in encompassing existing typologies, ongoing exploration into emerging spaces is crucial. Future research endeavors could explore and classify novel types of innovation spaces that might surface, reflecting the dynamic nature of innovation ecosystems.

Moving forward, several intriguing avenues for future studies emerge. One key area of exploration involves understanding the evolution of innovation spaces' value propositions over time. Investigating the factors and drivers behind spaces' choices between exploration and exploitation networks could offer valuable insights into strategic decision-making within these environments.

In addition, delving into organizational changes triggered by spaces opting for formal versus informal networks presents an avenue for understanding the structural adaptations within these entities. Moreover, critically examining whether all spaces labeled as "innovation spaces" genuinely foster innovation could offer a more nuanced perspective on their contributions to the innovation ecosystem.

Last, with the rapid advancement of technologies like Generative Artificial Intelligence (GAI), exploring their potential impact on how innovation spaces generate, and capture value stands as a compelling research direction. Understanding the interplay between these emerging technologies and the traditional functions of innovation spaces could shed light on their future trajectories and the dynamics of value creation within these environments.

These potential research avenues offer exciting prospects to deepen our understanding of innovation spaces and their evolving roles in the innovation context.

Conclusion

In today's landscape, innovation spaces have emerged as focal points for interaction, problem-solving, and the incubation of new products and services, fostering entrepreneurship and novel educational paradigms. The evolving role of these spaces within the innovation ecosystem has underscored a critical necessity in research, management, and society to unravel their complexities and establish a systematic classification. This paper undertakes the ambitious task of categorizing these innovation spaces through a taxonomy based on the intricate networks they foster, integrating insights from a methodology that amalgamates web content analysis and domain analysis.

The classification strategy deployed here transcends traditional taxonomies, delving into the nuanced dimensions of temporality, knowledge base, and performance within these spaces, aspects that have often been overlooked in prior literature. Our endeavor contributes significantly to elucidating the organizational structures and interplay of these spaces within the broader innovation landscape, shedding light on their dynamics and how they interface with the surrounding innovation ecosystem (González et al., 2020).

The proposed comprehensive and methodical categorization framework encapsulates diverse facets of these innovation spaces, offering a nuanced understanding of their orientations and functions (Corsaro et al., 2012). This multifaceted analysis not only deepens theoretical insights but also presents pragmatic implications for managerial decision-making. By discerning the innovation networks embedded within these spaces, this research provides guidance for stakeholders, enabling them to strategically navigate the varied landscapes of innovation facilitation, be it for fostering exploration-driven creativity or for driving market-oriented exploitation.

The theoretical implications arising from this classification framework extend the discourse on innovation networks, advancing our comprehension of the complex dynamics that underpin collaborative innovation spaces. Moreover, this endeavor initiates critical conversations about the strategic positioning of these spaces, their capacity for fostering diverse innovation strategies, and their pivotal role in nurturing creativity and problem-solving capabilities (Bogers & Zobel, 2017).

While this research offers a pioneering classification system, its contributions extend beyond taxonomy. The managerial recommendations emanating from this systematic categorization empower decision-makers to craft informed strategies tailored to the diverse natures of these spaces. Furthermore, by revealing the temporal, knowledge-centric, and performance dimensions, this research serves as a compass for future investigations, guiding scholarly endeavors toward deeper explorations of innovation spaces and their multifaceted roles in driving societal, technological, and economic progress (Thoring et al., 2020). The depth of understanding fostered by this categorization framework paves the way for an enhanced appreciation of these spaces as catalysts for innovation, collaboration, and transformative change.

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Availability of data and materials
The datasets generated and/or analyzed during the current study are available in the permanent web links indicated throughout the document.

Declarations

Competing interests
The authors declare that they have no competing interests.

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References

Allen, J., James, A. D., & Gamlen, P. (2007). Formal versus informal knowledge networks in R&D: A case study using social network analysis. *R&D Management, 37*(3), 179–196. https://doi.org/10.1111/j.1467-9310.2007.00468.x

Asheim, B., Boschma, R., & Cooke, P. (2011). Constructing regional advantage: Platform policies based on related variety and differentiated knowledge bases. *Regional Studies, 45*(7), 893–904. https://doi.org/10.1080/00343404.2010.543126

Atkinson, S., & Hap, M. A. E. (1996). Domain analysis for qualitative public health data. *Health Policy and Planning, 11*(4), 438–442. https://doi.org/10.1093/heapol/11.4.438

Auernhammer, J. (2020). Design research in innovation management: A pragmatic and human-centered approach. *R&D Management, 50*(3), 412–428. https://doi.org/10.1111/radm.12409

Berchicci, L. (2013). Towards an open R&D system: Internal R&D investment, external knowledge acquisition and innovative performance. *Research Policy, 42*(1), 117–127. https://doi.org/10.1016/j.respol.2012.04.017

Bernela, B., & Levy, R. (2015). Collaboration networks in a French cluster: Do partners really interact with each other? *Papers in Regional Science, 96*(1), 115–138. https://doi.org/10.1111/pirs.12170

Bloom, L., & Faulkner, R. (2016). Innovation spaces: Lessons from the United Nations. *Third World Quarterly, 37*(8), 1371–1387. https://doi.org/10.1080/01436597.2015.1135730

Bogers, M., & Zobel, A. (2017). The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation, 24*(1), 8–40. https://doi.org/10.1080/13662716.2016.1240068

Burns, T., & Stalker, G. M. (2006). Mechanistic and Organic Systems. In *Organizational Behavior 2*. Routledge.

Caccamo, M. (2020). Leveraging innovation spaces to foster collaborative innovation. *Creativity and Innovation Management, 29*(1), 178–191. https://doi.org/10.1111/caim.12357

Capdevila, I. (2013). Typologies of localized spaces of collaborative innovation. *SSRN*, 1–28. https://doi.org/10.2139/ssrn.2414402

Chesbrough, H. (2003). Open platform innovation: Creating value from internal and external innovation. *Intel Technology Journal, 7*(3), 5–9.

Corsaro, D., Cantù, C., & Tunisini, A. (2012). Actors' heterogeneity in innovation networks. *Industrial Marketing Management, 41*(5), 780–789. https://doi.org/10.1016/j.indmarman.2012.06.005

Cross, R., & Parker, A. (2004). *The hidden power of social networks: Understanding how work really gets done in organizations*. Harvard Business Press. https://hbsp.harvard.edu/product/2705-HBK-ENG

Dankulov, M. M., Melnik, R., & Tadić, B. (2015). The dynamics of meaningful social interactions and the emergence of collective knowledge. *Scientific Reports, 5*(1), 1. https://doi.org/10.1038/srep12197

Dittrich, K., Duysters, G., & de Man, A.-P. (2007). Strategic repositioning by means of alliance networks: The case of IBM. *Research Policy, 36*(10), 1496–1511. https://doi.org/10.1016/j.respol.2007.07.002

Dyer, J., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal, 21*(3), 345–367. https://doi.org/10.1002/(SICI)1097-0266(200003)21:3%3c345::AID-SMJ96%3e3.0.CO;2-N

Elo, S., Kääriäinen, M., & Kanste, O. (2014). Qualitative content analysis: A focus on trustworthiness. *SAGE Open, 4*(1), 1–10. https://doi.org/10.1177/2158244014522633

Estrada, E., & Gómez-Gardeñes, J. (2014). Communicability reveals a transition to coordinated behavior in multiplex networks. *Physical Review E, 89*(4), 042819. https://doi.org/10.1103/PhysRevE.89.042819

Evers, H. (2008). Knowledge hubs and knowledge clusters: Designing a knowledge architecture for development. *ZEF Working Paper Series, 27*, 1–24.

Fiore, A., & Rosani, G. (2018). Two questions to ask before you set up an innovation unit. *Harvard Business Review*, 1–10. https://hbr.org/2018/07/two-questions-to-ask-before-you-set-up-an-innovation-unit

Fonseca, D., & Sanchez-Sepulveda, M. (2022). Characterization of spaces and didactic units for the improvement of diversity gaps. In P. Zaphiris & A. Ioannou (Eds.), *Learning and collaboration technologies. Designing the learner and teacher experience* (pp. 335–346). Cham: Springer. https://doi.org/10.1007/978-3-031-05657-4_24

Fuzi, A. (2015). Co-working spaces for promoting entrepreneurship in sparse regions: The case of South Wales. *Regional Studies, Regional Science, 2*(1), 462–469. https://doi.org/10.1080/21681376.2015.1072053

Galuppo, L., Kajamaa, A., Ivaldi, S., & Scaratti, G. (2019). Translating sustainability into action: A management challenge in FabLabs. *Sustainability, 11*(6), 1676. https://doi.org/10.3390/su11061676

Geldes, C., Heredia, J., Felzensztein, C., & Mora, M. (2017). Proximity as determinant of business cooperation for technological and non-technological innovations: A study of an agribusiness cluster. *Journal of Business & Industrial Marketing, 32*(1), 167–178. https://doi.org/10.1108/JBIM-01-2016-0003

Gomes, P. (2016). Stanford FabLearn's Paulo Blikstein on the efficacy of Maker. *EdSurge*. https://www.edsurge.com/news/2016-05-26-stanford-fablearn-s-paulo-blikstein-on-the-efficacy-of-maker-ed-it-s-about-process-not-products

González, N., Ching, L., Fernández, J., Reynaga, C., Santamaría, D., Díaz, A., & Cortés, A. (2020). FabLabs in vulnerable communities: STEM education opportunities for everyone. *International Journal on Interactive Design and Manufacturing, 14*(4), 1535–1555. https://doi.org/10.1007/s12008-020-00744-y

Greve, C., & Ysa, T. (2023). Handbook on strategic public management. *Edward Elgar Publishing Ltd*. https://doi.org/10.4337/9781789907193

Grillitsch, M., Martin, R., & Srholec, M. (2017). Knowledge base combinations and innovation performance in Swedish regions. *Economic Geography, 93*(5), 458–479. https://doi.org/10.1080/00130095.2016.1154442

Groenendyk, M., & Gallant, R. (2013). 3D printing and scanning at the Dalhousie University Libraries: A pilot project. *Library Hi Tech, 31*(1), 34–41. https://doi.org/10.1108/07378831311303912

Guthrie, C. (2014). *Empowering the hacker in us: A comparison of fab lab and hackerspace ecosystems*. 5th LAEMOS—Latin American and European Meeting on Organization Studies, Havana, Cuba. https://doi.org/10.13140/2.1.4536.2881

Hagedoorn, J., & Duysters, G. (2002). External sources of innovative capabilities: The preferences for strategic alliances or mergers and acquisitions. *Journal of Management Studies, 39*(2), 167–188. https://doi.org/10.1111/1467-6486.00287

Håkansson, H., & Olsen, P. (2012). Innovation management in networked economies. *Journal of Business Market Management, 5*(2), 79–105.
Halbinger, M. (2018). The role of makerspaces in supporting consumer innovation and diffusion: An empirical analysis. *Research Policy, 47*(10), 2028–2036. https://doi.org/10.1016/j.respol.2018.07.008
Hallin, C., & Lipka, N. (2023). *Reinventing local government through collective intelligence and artificial intelligence: How a Danish municipality harnesses citizen insights*. Routledge.
Hassan, Z. (2014). *The Social Labs Revolution: A new approach to solving our most complex challenges*. Berrett-Koehler Publishers.
Hasti, H., & Amo-Filva, D. (2023). *A grey web analysis of existing STEAM diversity initiatives*. Springer Nature Singapore.
Johns, J., & Hall, S. (2020). 'I have so little time […] I got shit I need to do': Critical perspectives on making and sharing in Manchester's FabLab. *Environment and Planning a: Economy and Space, 52*(7), 1292–1312. https://doi.org/10.1177/0308518X19897918
Ketchen, D., Ireland, R., & Snow, C. (2007). Strategic entrepreneurship, collaborative innovation, and wealth creation. *Strategic Entrepreneurship Journal, 1*(3–4), 371–385. https://doi.org/10.1002/sej.20
Klerkx, L. W. A., & Aarts, N. (2013). The interaction of multiple champions in orchestrating innovation networks: Conflicts and complementarities. *Technovation, 33*(6–7), 193–210. https://doi.org/10.1016/j.technovation.2013.03.002
Leminen, S., Westerlund, M., & Nyström, A.-G. (2012). Living Labs as open innovation networks. *Technology Innovation Management Review, 2*(9), 6–11.
Liu, J., Chaminade, C., & Asheim, B. (2014). *The geography and structure of global innovation networks: A knowledge base perspective*. Routledge.
Marcelloni, C. (2023). The 3 T's framework of social innovation labs. *CERN IdeaSquare Journal of Experimental Innovation, 3*(1), 8–14. https://doi.org/10.23726/cij.2019.872
March, J. G. (1991). Exploration and exploitation in organizational learning. *Organization Science, 2*(1), 71–87.
Martin, R., & Moodysson, J. (2013). Comparing knowledge bases: On the geography and organization of knowledge sourcing in the regional innovation system of Scania, Sweden. *European Urban and Regional Studies, 20*(2), 170–187. https://doi.org/10.1177/0969776411427326
Memon, A. B., Meyer, K., Thieme, M., & Meyer, L.-P. (2018). Inter-InnoLab collaboration: An investigation of the diversity and interconnection among Innovation Laboratories. *Journal of Engineering and Technology Management, 47*, 1–21. https://doi.org/10.1016/j.jengtecman.2017.11.003
Montes, J., Batz, A., & Espejo, J. (2023). Laboratorio Social: Innovación y experimentación para la economía formal e inclusiva. Editorial Universidad del Rosario.
Morel, L., Dupont, L., & Boudarel, M. (2018). *Innovation Spaces: New places for collective intelligence?* Wiley.
Nambisan, S. (2009). Platforms for collaboration. *Stanford Social Innovation Review, 7*(3), 44–49. https://doi.org/10.48558/48MV-NK43
Narayanan, V. (2017). Idea labs: Instituting an innovation discovery process capable of sustaining the business. *Strategy & Leadership, 45*(1), 27–36. https://doi.org/10.1108/SL-12-2016-0089
Naveh, E. (2005). The effect of integrated product development on efficiency and innovation. *International Journal of Production Research, 43*(13), 2789–2808. https://doi.org/10.1080/00207540500031873
Nooteboom, B. (2006). Innovation, learning and cluster dynamics. In *Clusters and Regional Development* (pp. 155–181). Routledge
Ojasalo, J. (2004). Key network management. *Industrial Marketing Management, 33*(3), 195–205. https://doi.org/10.1016/j.indmarman.2003.10.009
Ooms, W., & Piepenbrink, R. (2021). Open innovation for wicked problems: Using proximity to overcome barriers. *California Management Review, 63*(2), 62–100. https://doi.org/10.1177/0008125620968636
Pascale, P., & Resina, J. (2020). Prototipando las instituciones del futuro: El caso de los laboratorios de innovación ciudadana (Labic). *Iberoamerican Journal of Development Studies, 9*(1), 6–27. https://doi.org/10.26754/ojs_ried/ijds.437
Patton, M. (2014). Qualitative research and evaluation methods. SAGE.
Pittaway, L., Robertson, M., Munir, K., Denyer, D., & Neely, A. (2004). Networking and innovation: A systematic review of the evidence. *International Journal of Management Reviews, 5–6*(3–4), 137–168. https://doi.org/10.1111/j.1460-8545.2004.00101.x
Plum, O., & Hassink, R. (2011). Comparing knowledge networking in different knowledge bases in Germany. *Papers in Regional Science, 90*(2), 355–371. https://doi.org/10.1111/j.1435-5957.2011.00362.x
Powell, W. (1998). Learning from collaboration: Knowledge and networks in the biotechnology and pharmaceutical industries. *California Management Review, 40*(3), 228–240. https://doi.org/10.2307/41165952
Schiuma, G., & Santarsiero, F. (2023). Innovation labs as organisational catalysts for innovation capacity development: A systematic literature review. *Technovation, 123*, 102690. https://doi.org/10.1016/j.technovation.2023.102690
Thoring, K., Mueller, R., Desmet, P., & Badke, P. (2020). Spatial design factors associated with creative work: A systematic literature review. *AIEDAM, 34*(3), 300–314. https://doi.org/10.1017/S0890060420000232
Trott, P., & Hartmann, D. (2009). Why "open innovation" is old wine in new bottles. *International Journal of Innovation Management, 13*(04), 715–736. https://doi.org/10.1142/S1363919609002509
Van Aken, J. E., & Weggeman, M. P. (2000). Managing learning in informal innovation networks: Overcoming the Daphne-dilemma. *R&D Management, 30*(2), 139–150. https://doi.org/10.1111/1467-9310.00164
Van Holm, E. (2014). What are makerspaces, hackerspaces, and Fab Labs? *SSRN*, 1–24. https://doi.org/10.2139/ssrn.2548211
Witt, A., Umpierre, L., & Silva, F. (2023). Citizen laboratories in the federal universities of Brazil: Innovation and social contribution in the citizen science scenario. *Revista Digital De Biblioteconomia e Ciência Da Informação, 21*, 1–15. https://doi.org/10.20396/rdbci.v21i00.8673329/32124
Xie, X., Fang, L., & Zeng, S. (2016). Collaborative innovation network and knowledge transfer performance: A fsQCA approach. *Journal of Business Research, 69*(11), 5210–5215. https://doi.org/10.1016/j.jbusres.2016.04.114

Yang, M., Kang, X., Wu, Y., & Yang, C. (2016). A study on the comparison and inspiration for operation mode of the Makerspace brand in China and America. *Cross-Cultural Design, 9741*, 316–325. https://doi.org/10.1007/978-3-319-40093-8_32

Youtie, J., & Shapira, P. (2008). Building an innovation hub: A case study of the transformation of university roles in regional technological and economic development. *Research Policy, 37*(8), 1188–1204. https://doi.org/10.1016/j.respol.2008.04.012

Zheng, J., Shi, L., & Jiang, T. (2022). What mechanism design helps to realize the innovation function of maker-spaces: A qualitative comparative analysis based on fuzzy sets. *PLoS ONE, 17*(9), 1–15. https://doi.org/10.1371/journal.pone.0274307

Zurbriggen, C., & Lago, M. (2019). An experimental evaluation tool for the Public Innovation Lab of the Uruguayan Government. *Evidence & Policy: A Journal of Research, Debate and Practice, 15*(3), 437–451. https://doi.org/10.1332/174426419X15537488717501

Publisher's Note

Jose Montes received the Ph.D. degree in science, technology and society from the Université du Québec à Montréal. He is currently a full professor of innovation, entrepreneurship, global business environment and qualitative methods at the School of Management, Universidad del Rosario (UR). He is Academic Director of the Master's degree in Innovation and Entrepreneurship of the UR Graduate Business School, Coordinator of the Organizational Complexity Research Team, (ad hoc) Reviewer of Academy of Management Review, and member of the UR Innovation Center. He has obtained several national and international awards for his research contributions. His research, teaching and consulting interests focus on sustainable management of technological innovations, digital transformations and entrepreneurship.

Aglaya Batz holds a Ph.D. in economic public policy (Dr. rer. pol) from the Brandenburg University of Technology (Germany), a Master of Science (M.Sc.) in technology and innovation management, she is also a specialist in business administration and holds a bachelor's degree in systems and telecommunications engineering. She has worked on social innovation projects, industrial innovation, business model innovation, corporate social responsibility, as well as technology transfer projects. Her main line of research is focused on analyzing knowledge flows in industrial innovation networks. She is currently the director of the innovation center and full professor at the Business School of the Universidad del Rosario.

Lizeth Fernanda Serrano Cárdenas Industrial Engineer. Master in Industrial Engineering. Ph.D. in Modeling and Public Policy Management. She has developed training programs in technology transfer with the World Intellectual Property Organization and Oxford University. She is certified in Design Thinking methodology by Tecnologico de Monterrey. Trained by the Presencing Institute of the MIT Sloan School of Management in the Social Presence Theater approach for the design of systems change futures. Currently, she is a Research Professor at the Innovation Center of the School of Management at Universidad del Rosario. She has more than 10 years of experience as a researcher and consultant in public and private organizations in her areas of interest: Strategic Innovation, Social Entrepreneurship, Public Innovation, Social Innovation, Knowledge Management and Agile Project Management.