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# Learning in Cities from Within and Across Cities: A Scoping Review

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## Abstract

Cities evolve rapidly while providing both opportunities and posing challenges. To cope with the emerging behaviours of cities, contextual innovations and development are essential. Driving innovations through the learning of contextual knowledge in cities is crucial. In this study, we explore relevant studies to identify the frameworks for human-centric innovations in cities that consider learning from within and/or across cities. We analyse how learning in cities has been addressed in those studies and find that even though some aspects of learning in cities have been studied, a comprehensive framework for how cities can learn as an innovation ecosystem is missing. Based on the findings of a scoping review and insights from the theories of the Triple, Quadruple and Quintuple helices of innovation, we present a high-level conceptual model for cities as innovation ecosystems. The model is aimed to support sustainable human-centric development through the understanding of city learning through multilevel interactions and feedback.

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### Keywords

City learning – Innovation ecosystems – Learning within cities – Learning across cities – Sustainable human-centric development – Scoping review

## Introduction

Urbanisation and technological innovations have propelled the growth of cities. Cities form the economic backbone of the world, wherein, by 2025, it is expected that 60% of the global GDP will be generated by 600 cities (Piva, 2017). Presently, around 55% of the world's population resides in cities, constituting only 2% of the global land space, and it is estimated that 68% of the world's population will be living in cities by 2050 (Correia et al., 2018). Both business and welfare perspectives have driven this growth phenomenon of cities. Technological innovations, with the ability to open up vast opportunities for earning profits while generating new genres of employment, have been providing thrust for developing cities. The disruptive demographic and economic changes occurring in and around cities necessitate effective and timely innovations to respond to the emerging challenges of competitive growth, rising inequality and environmental degradation for ensuring sustainable human-centric development of the cities. Policymakers and social scientists, on the other hand, strive to maximise social welfare and ensure ecological sustainability.

The focus on addressing the emerging challenges and opportunities in cities has driven the concept of smart sustainable cities (UNECE, 2015; ITU, 2016). A smart sustainable city has been described by the United Nations Economic Commission for Europe (UNECE) (UNECE, 2015) as "an innovative city that uses Information and Communication Technologies (ICT) and other means to improve the quality of life, efficiency of urban operations and services, and competitiveness while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects". This concept of cities has been further expanded to Human Smart Cities (Hanna, 2016) that has been formally described in de Oliveira et al. (2015) as a concept for improving the quality of life of the citizens, leading to well-being and happiness through services that can be defined as new and innovative "ad hoc" services developed by the local government in collaboration with the citizens and other stakeholders, to tackle the wicked problems which are challenging to resolve due to their complex and interconnected



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nature. Complex, social-environmental issues are classified as "wicked problems" (Rittel, 1967) because the proposed solutions to tackle them are mutually and constantly reshaping one another (Duckett et al., 2016).

The common method for bringing innovations in cities has been through policy transfers by sharing and replicating best practices from developed cities to developing cities (European Commission, 2016, 2017a,b,c). Developmental policies following such approaches of replication may not produce desired outcomes (Calzada, 2020; Vandervyvere, 2017; Marchetti et al., 2019; Graham, 2002; Glasmeier and Nebiolo, 2016; Stead, 2012; Nagorny-Koring, 2019). In such replicative transfers of policies or sharing of best practices, learning gets reduced to replication, whereas learning is not equivalent to replication. Calzada (2020) argues that such replication approaches are often disconnected from the stakeholders and are simplistic, short term and driven by profit. Contextual knowledge is a prerequisite for sustainable innovations in a city to cope with the city's emerging economic, social and environmental changes. However, the knowledge learnt in different cities is not homogeneous because the cities have distinct contextual requirements and resources with different administrative settings (Calzada, 2020). These concepts reveal the importance of continuous learning about the local contextual challenges and opportunities through interactions and feedback from experiences for designing interventions that can yield the desired results.

To understand how a city can learn for sustainable, human-centric innovations, it is essential to comprehend what comprises a city. There are different elements of a city, such as citizens, collective bodies or groups of individuals, administrators, organisations/institutions and service systems, that create and use physical infrastructure such as residential/commercial buildings, industries and roadways built over a certain area of land (Bibri, 2019; Pham, 2017). The elements within a city, which can have positive or negative interdependencies among themselves, interact with each other and across cities to form a complex ecosystem. The Triple, Quadruple and Quintuple Helix models (Carayannis et al., 2022) identify several dimensions that indicate these elements of cities, and these models have been used to describe cities as interconnected networks where various dynamics converge, including intellectual capital, industrial development, and societal participation (Pique et al., 2019). These interactions create spaces within cities that facilitate the exploitation of knowledge. The density of relationships among universities, wealth creation, and democratic governance lead to the development of cities as innovation ecosystems (Granstrand and Holgersson, 2020). While discussing technological and social innovations through the Triple Helix approach and considering



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the complexities of interactions in a city, the necessity of taking an evolutionary and a system perspective for cities for their local innovations has also been emphasised in Gebhardt (2015).

Cities as innovation ecosystems behave like large complex organisations where various interconnected elements interact with each other (Mayangsari and Novani, 2015). Such an ecosystem comprises individuals with diverse competencies, values, and needs, wherein stakeholders are defined as groups or individuals who can influence or be influenced by the organisation's objectives. The evolution of a city as an innovation ecosystem shares similarities with a Complex Adaptive System, where the behaviour of the system goes beyond the simple sum of its individual elements' behaviours, and the ecosystem as a whole evolves due to the interactions between its elements (Sanders, 2008; Nel et al., 2015; Ulysses, 2017; Caputo et al., 2019). Interventions within such ecosystems lead to new system behaviour emerging through adaptations to the temporary impacts (van Geert, 2019). Interventions must be continually innovated to address the emergent behaviour in a city based on the feedback obtained from experiences and interactions. Isolated analyses of the impacts of a city's elements or service systems, without an ecosystem view of a city, cannot provide accurate insights into the innovation and development of a city. These phenomena highlight the crucial role of knowledge management in the sustainable development of human-centric cities (Israilidis et al., 2021) where the focus has been on three key areas: (1) socio-technical approaches, (2) integrating knowledge-sharing perspectives and (3) developing organisational learning capabilities.

Learning is an integral part of the process of innovation wherein knowledge of contextual requirements, challenges and opportunities are the primary steps for innovating a solution for any system. Learning can take place within a city from the elements within the city. A city also learns from other cities, which we refer to as learning across cities or city-to-city learning. In the rest of this study, the term "city learning" has been used to refer to both the types of learning wherein a city can learn from the elements within the city and also from across cities. The knowledge from the interactions and the feedback between the city elements and across cities can propel innovations to address emerging challenges and opportunities. To ensure economically, socially and environmentally sustainable city development, the contextual requirements of a city's stakeholders must be considered while developing innovations for the city ecosystem. Innovations should be based on the knowledge learnt from the feedback of interactions and experiences between the different elements of the city ecosystem. For example, a city's mobility services are affected by its



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roadway planning. Similarly, traffic congestion can affect the city's air pollution levels, work-life quality and education systems. Environmental factors, in turn, directly affect the quality of life and healthcare systems.

A framework for city learning can greatly help in ensuring the city's economic, social and environmental sustainability by illustrating what the learning implies and how the learning can take place in a city. To explore city learning, our research questions for this study are:

RQ1. What are the existing frameworks for developing cities through human-centric innovations considering city learning?

RQ2. What has been addressed as learning in cities in the frameworks identified through RQ1?

In this study, we conduct a scoping review (Peters et al., 2015) to map the relevant literature to answer our research questions. Through the analysis of the scoping review, we develop a high-level conceptual model of interrelationships and interactions between city elements, facilitating city learning while considering the ecosystem view of a city.

The rest of this study is organised as follows: Section 2 describes the background of this study, Section 3 illustrates details of the methods for conducting the scoping review, and Section 4 presents the results of the scoping review. In Section 5, the discussion based on the scoping review is presented, and we propose a conceptual model of a city ecosystem for the interrelationships and interactions between its elements that can drive city learning. The conclusion of this study is provided in Section 6.

## Background

Cities can be visualised as systems wherein physical spaces within the natural environment are developed by a community of living organisms, human beings in this case, by developing and utilising several non-living components such as physical infrastructures, technological artefacts and services for the city residents. An understanding of the evolution of cities across time and space highlights that population size, density and heterogeneity form the fundamental properties of urban settlements (Angel et al., 2016). The socio-economic and cultural heterogeneity in a city catalyses a plethora of interactions (intentional or serendipitous, fleeting and consequential, anonymous or long-lasting, driven by economic imperatives or sustained by shared ideological commitments),



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resulting in social learning (von Sch¨onfeld et al., 2020). The parks, cafes, and sidewalks of contemporary cities or the plazas and marketplaces of ancient cities have provided the settings for social interactions (Stanley et al., 2012). Cities are places where "energised crowding" (Westlund and Larsson, 2016; Serafinelli and Tabellini, 2021) of people takes place, which enables creative and innovative possibilities for generating growth and change through the networks of interactions between different individual and institutional entities, service systems and various social structures. However, not all the outcomes of "energised crowding" have been positive traits; for example, increased poverty, crime and social alienation have also been outcomes of social interactions (Smith, 2019).

The UN Sustainable Development Goal (SDG) 11 for "Sustainable cities and communities", (United Nations, 2015), focuses on developing people-centred innovative cities that use ICT and other means to improve people's well-being, utilising ICT and various approaches to enhance the overall quality of life, urban functionality and competitiveness, while considering the requirements of current and future generations across the economic, social, environmental and cultural dimensions. In Granstrand and Holgersson (2020: 1) we find a detailed definition of an innovation ecosystem as "the evolving set of actors, activities, and artefacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors". A city can be viewed as an innovation ecosystem that evolves like a living organism while adapting to the interactions and feedback among its diverse internal and external elements.

Cities encompass a broad spectrum of concepts and are of interest to multiple research domains. In this study, we have focused on a few of these concepts that we consider most relevant for city learning. Thus, the following subsections focus on the concept of Smart Cities, the Triple, Quadruple and Quintuple Helix Models of innovation systems (Carayannis and Campbell, 2010) in relation to cities as innovation systems, and the different learning approaches that are relevant to the research on city learning.

### *Smart Cities*

Learning in cities or city learning has often been discussed in the context of smart cities. There are numerous definitions of smart cities (Albino et al., 2015; Kirimtat et al., 2020), and many of them perceive a smart city as one that is driven by technology and takes a very technology-centric view. Several European projects have focused on this theme with endeavours to develop a technology infrastructure to support many activities in a city (Perez et al.,



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2020; REPLICATE Project, 2021), and to document successful digital ecosystems and pilot solutions, with the aim to replicate similar solutions in other cities (Petersen et al., 2021a). Making data about a city visible to its citizens has also been considered as a means of sharing knowledge and raising awareness among people, such as city dashboards (UCL, 2012). Researchers have also explored novel uses of technology to study, understand and propose innovative ideas to manage cities (MIT, 2016).

More recently, the concept of a digital twin of a city that not only includes sensor data but combines other urban data to provide new insights and knowledge about a city has gained the interest of many stakeholders, such as urban designers and service providers in cities (Hämäläinen, 2021). The data from digital twins have also been used to enhance visualisation possibilities, e.g. using Virtual Reality technologies (Mohammadi and Taylor, 2020). One of the limitations of the digital twin and the barrier to its uptake in cities has been its lack of consideration of the city as a socio-technical system and the interplay of humans and technology.

Many researchers have considered the concept of smart cities with a human or citizen-centred view, such as Petersen et al. (2015) and Hanna (2016). Their focus has been on the use of technologies to enhance the well-being of the citizens and by engaging them in co-design and other interactive processes. They highlight the notion of the city evolving as a result of the engagement activities. This relates to the view that a city must have the ability to learn in order to sustainably evolve in the future (Calzada, 2020).

The work on smart cities is mostly in the urban context, although many of the research themes are related to the natural environment and actions such as the trend to decarbonise our societies and climate-neutral solutions. There has been a global interest in learning and adopting climate-neutral solutions across cities to create a sustainable future for everyone. A global network of mayors of nearly 100 cities forms the C40 network to confront the climate crisis in unison (C40, 2019). A C40 knowledge hub is compiled to share knowledge across cities about sustainable solutions from which cities learn about policies from each other Lee and Van de Meene (2012). Another global initiative, funded by the European Union and the United Nations Development Fund (UNDP), is the Urban Learning Centre (UNDP, 2020), an initiative to re-imagine urban and local spaces for positive transformative change and future-readiness. The network consists of several cities across the world, and it provides new learning and networking opportunities within the network of cities and regions, enabling a learning ecosystem. The main support for learning appears to be sharing cases via a passive knowledge hub, and a systematic and structured



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way to actively share knowledge and experiences through the participation and engagement of all relevant stakeholders for collaborative development is currently missing.

### *Triple, Quadruple and Quintuple Helix Models*

The Triple, Quadruple, and Quintuple Helix models are important in describing and analysing cities as innovation ecosystems (Carayannis and Campbell, 2010). These models have drawn inspiration from the research on the knowledge economy and innovation systems and democratisation of knowledge for making it accessible for creating new knowledge and knowledge spaces through interactions among multiple actors (Carayannis and Campbell, 2021).

The Triple Helix model was originally proposed by Etzkowitz and Leydesdorff (1995) to emphasise the roles of the University-Industry-Government relations in innovation in a knowledge economy. One of the criticisms of the Triple Helix model was the focus on the idea that knowledge-intensive activities would lead to economic growth and that it did not take into account the role of civil society. The Quadruple Helix emphasises the role of democracy in knowledge and innovation and enhances knowledge production by energising civil society and the media (Carayannis and Campbell, 2010). It provided a broader contextualisation of the Triple Helix model by aiming to bridge the gap between innovation and civil society and introduced the dimensions of media and civil society. The Quadruple Helix model incorporates the "dimension of democracy" or the "context of democracy" for knowledge, knowledge production, knowledge application and innovation. The Quintuple Helix goes even further by incorporating the perspective of "natural environments of society" to broaden the context of knowledge production and by introducing the concept of "social ecology" (Carayannis et al., 2022). The Quintuple Helix model emphasises the interactions between society and the natural environment (Etzkowitz and Leydesdorff, 2000). The dimensions included in the Quintuple Helix model also provide a sound basis to address the wicked problems in cities, such as in the context of urban development and planning, environmental policies and social welfare. Examples of the application of the Triple, Quadruple and Quintuple Helix models in cities are reported in Pique et al. (2019), Kuzior and Kuzior (2020) and Petrushenko and Grunwaldt (2021) respectively.

The Quadruple Helix and Quintuple Helix models for innovation systems are advanced models that aim to understand and address the complex nature of knowledge production and application in a societal context (Carayannis and



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Campbell, 2021). In this context, Leydesdorff and Smith (2022) have argued that the dimensions of the Quadruple and Quintuple Helix models could be recombined into interacting triple helices, emphasising the need for interactions among triple or a higher order of helices or dimensions.

Cities have been considered smart within the framework of the Triple Helix model when future internet advancements effectively integrate ICTs to create networks that serve society's needs (Deakin, 2014). These networks go beyond generating intellectual capital and wealth; they also nurture the environmental capacity, ecology, and vitality of spaces. The participatory governance and direct democracy characteristic of these cities play a crucial role in opening up, enhancing value, and constructing such spaces. Interactions among the entities, e.g. the universities, private sector, government, civil society and the natural environment, are key to knowledge growth. The models view the natural environments of society and the economy as drivers for knowledge production and innovation. The dimensions identified in these models are central to understanding the urban context and how society and its environments evolve. They have also been discussed in the literature as models that could support the circulation of knowledge by drawing upon existing knowledge to create new "knowledge spaces" (Etzkowitz and Zhou, 2017). The production of new knowledge can be considered as a learning process that takes place in the context of knowledge production (Carayannis et al., 2022). Of particular interest to the research on learning in cities, the regulatory dimension has been proposed as an additional dimension to the Triple Helix model (Emeis and Fallmann, 2022). The authors argue that currently, regulations hinder smart cities from progressing. Instead, regulations could be the drivers for sustainable transitions, e.g. by aligning with the UN's SDGs (United Nations, 2021).

### *Learning Approaches*

Modelling the city ecosystem comprising its elements, their relations, structures, and interactions can lead to understanding how a city can innovate through learning. Multi-Agent-Based simulation platforms pose an option for modelling city ecosystems and analysing city learning. In these simulation models, digital models artificially represent cities that are fed with data from the Internet of Things (IoT) sensors for specific city systems such as traffic systems. Studies regarding how to efficiently use sensor data in such simulation models representing cities have been conducted (Crooks et al., 2021; Clemen et al., 2021; Guastella et al., 2019). Using general principles, functionality, and the architecture of the digital multi-agent platform, a Resource-Demand (RD)



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Model has also been conceptualised for developing smart cities (Kozhevnikov et al., 2019), which views a smart city as a complex system, which is alive and constantly evolving and adapting. Using this approach, the model describes how a city can self-organise and evolve by utilising a set of Key Performance Indicators (KPI) like business, recreation, comfort, transport, environment, goods availability, medical care, education and prices for services. In this approach, the services learn resource-demand relations among themselves for their adaptation without citizen participation.

One of the areas of learning related to cities as well as many other contexts is that of Transfer Learning (TL) (West et al., 2007), which is a research area in Machine Learning (ML) that focuses on using knowledge gained while solving one problem and applying it in another instance for a related problem. TL bears similarities with the perspective of a city ecosystem learning from other cities in relevant contexts. Several TL techniques have been developed for different computer applications, as shown in (Zhuang et al., 2020) and can be integrated into the multi-agent-based simulation models. These techniques have been adapted and also used for modelling learning across cities to find suitable service system specifications for a city based on the knowledge acquired from other cities (Wei et al., 2016; Yao et al., 2019). The techniques have been used to propose the transfer of contextualised knowledge of system/service designs from lighthouse cities to developing new cities. The service system designs for cities depend on several interdependent elements of the city ecosystem, whereas the mathematical optimisation techniques, which form the core of all ML methods (Sun et al., 2019), cannot operate on interdependent variables. Due to this reason, sole reliance on ML methods is not suitable for modelling and analysing societal scenarios that have non-linear evolutionary behaviours due to their interdependent adaptive social actors. Furthermore, even though the digital models using simulation platforms can incorporate TL techniques and diverse sensor data, they lack consideration for citizen engagement. Studies in Oliveira et al. (2014); de Oliveira et al. (2015) have highlighted that citizen-driven, smart and inclusive environments with the opportunity for continuous communication between the citizens and the government are essential for developing human-centric cities.

The concept of Learning Cities has been termed crucial for achieving the UN's SDGs, particularly SDG 4, which focuses on inclusive education and Lifelong Learning opportunities (UNESCO, 2021). UNESCO defines Learning Cities as places that provide Lifelong Learning opportunities through different actors like governments, institutions, and communities. Technology, especially ICT solutions, plays a key role in facilitating Lifelong Learning by improving

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access to resources and engagement across society. Public-private partnerships and government collaboration are crucial for achieving education goals and the SDGs (United Nations, 2022). Learning in the context of smart cities has been referred to as smart city learning, which entails people learning in the city or urban areas, following the principles of Lifelong Learning for citizens, anytime, anywhere and facilitated by digital technologies (Gianni and Divitini, 2015).

The concept of Real-World Laboratories (RWLs) has been used for innovative transformations of districts and cities (Singer-Brodowski et al., 2018). RWLs aim to facilitate learning processes as part of their transformative objectives by generating and testing the knowledge required for a sustainable transformation of existing cities. The labs fulfil multiple roles, acting as a learning environment, a platform for networking, and an infrastructure that empowers the undertaking of sustainability experiments driven by a city's needs and interests. However, there is a lack of understanding, planning, and evaluation of the learning dimension of RWLs.

Living Labs (LLs) (ENOLL, 2022) have extended the RWL approach and have been used in the urban context (Gebhardt, 2020). This approach has been inspired by the perspectives of Lifelong Learning (Power and Maclean, 2013) and focuses on the collaboration of citizens through activities for codesign, co-creation and feedback (Lucchesi and Rutkowski, 2021). LLs in urban areas, or Urban Living Labs (Molinari et al., 2015: 98) have been described as "socio-digital innovation environments in realistic city-life conditions based on multi-stakeholder partnerships that effectively involve citizens in the co-creation and co-production of new or reformed public services and infrastructures". LLs consider collaboration through interactions for sharing their common wishes, interests and ideas, through meeting in person and also through digital tools such as ICT platforms. LLs have also been studied to highlight the concept of governance depicting governance actors and their role in the transformation process based on, for example, the Triple Helix model of innovation (Izdebska et al., 2022). Nevertheless, these LLs have been one-off experiments for specific city requirements, mostly confined to small neighbourhoods within a city and do not consider the holistic view of a city as an ecosystem. A standardised framework for LLs addressing city learning is also missing. A European project, MyNeighbourhood, had the aim of bringing about city transformation, focusing on one neighbourhood at a time by actively involving citizens and various stakeholders in co-creation and co-design activities. The project's primary objective was to facilitate the exchange of experiences and knowledge across neighbourhoods and pilot



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projects, fostering mutual learning. In the context of learning in Human Smart City, the MyNeighbourhood project has been analysed in Petersen et al. (2015), which highlighted that even though it can be perceived that learning takes place in city neighbourhoods at the individual, group and institutional levels by gaining contextual knowledge through activities such as co-creation and engagement of citizens, how the learning takes place at the city level remains an area for research.

It is evident from the existing literature that there are no one-size-fits-all "best practices" for cities (Meijer, 2016), and they cannot simply be copied from one city to another without human-centric contextualisation for respective city requirements, resources, challenges and opportunities (Calzada, 2020). Nevertheless, from the study in Schuurman et al. (2016), it can be realised that the knowledge generated within a specific city context may transcend the boundaries of the corresponding contextual settings in which the learning takes place. Even though there is limited empirical research available on city-to-city learning, we find an analysis in Ilgen et al. (2019), which shows how the exchange of relevant knowledge between Rotterdam and Mexico City for building resilience for water-related challenges can lead to city-to-city learning. In Moodley (2020), stages in city-to-city learning have been modelled based on the insights gained in the context of the South African cities of Malawi and Namibia that participated in a mentorship programme coordinated by the international United Cities and Local Governments (UCLG).

The learning process has been identified as central to knowledge production in innovation systems (Carayannis, 2001). As such, the learning process is described as comprised of many processes, namely (1) learning, (2) learning to learn, and (3) learning how to learn. These processes have been described in (Carayannis and Campbell, 2010, 2021), in relation to the Quintuple Helix model for innovation.

From the organisational learning perspective, cities have been perceived as large-scale organisations (Papageorgiou and Demetriou, 2019), which present promising grounds for understanding city learning. Seymoar et al. (2009) gives an overview of how cities learn akin to organisational learning by studying the data compiled through participant observation and a survey of members of the Sustainable Cities: PLUS Network. There are several frameworks to describe organisational learning (see for example, Crossan et al., 1999; Petersen et al., 2021b), and providing in-depth analyses of these is beyond the scope of this article. However, there has been very limited focus on establishing a framework design for developing human-centric sustainable city ecosystems by innovations through learning from within and across cities.

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## Methods

In this study, we aim to identify relevant frameworks from existing studies that consider city learning for city developments through innovations to answer our RQs. Due to the presence of multiple interconnected concepts and a lack of a comprehensive overview, we have opted for the scoping review method to examine the existing literature systematically.

A scoping review is a type of literature review that is suitable when the topic of interest has not been thoroughly explored or is complex or diverse in nature (Peters et al., 2015). It serves as a means to evaluate the potential volume of literature and obtain a comprehensive overview of existing research. In the case of city learning, which encompasses a broad and interdisciplinary domain, it is helpful to narrow down and focus on relevant literature before undertaking a systematic literature review.

To conduct our scoping review, we have followed the stages outlined in the methodological framework for conducting a scoping review (Arksey and O'Malley, 2005). These stages encompass 1) identification of the research question, 2) identification of relevant studies, 3) the selection of appropriate studies, 4) organisation and analysis of collected data, and 5) synthesising, summarising, and reporting of the results.

We conducted a scoping review of existing research publications, and upon identifying the relevant frameworks, we explored how they address city learning. We have followed the gold standard guidelines from the Preferred Reporting Items for Systematic Review and Meta-Analyses (PRISMA) model for identifying the relevant studies and final study selection for the scoping review (Moher et al., 2009).

### *Search Strategy*

We have conducted a systematic search using online research databases for peer-reviewed studies to identify the relevant work in the context of city learning. We have included the online databases of SpringerNature, ScienceDirect, IEEE, SAGE, ACM, Taylor & Francis, Emerald, Wiley, MDPI, Inderscience and IGI Global for this study. The search strings for this scoping review were framed considering two aspects of our research questions:

a) development of human-centric cities through innovation, and
b) frameworks for the development of the cities considering city learning.

The PICOC framework proposed in Papaioannou et al. (2016) has been used to frame a comprehensive set of search keywords for quantitative research according to population, intervention, comparison, outcome, and context



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TABLE 1 PICOC framework for framing search keywords

| | |
|---|---|
| Population | – |
| Intervention | Role of learning in developing cities as innovation ecosystems |
| Comparison | – |
| Outcome | Human Smart Cities, City-to-City Learning, City Learning |
| Context | City learning from within and across cities, Innovation ecosystems of cities |

TABLE 2 Search keywords

| | | |
|---|---|---|
| | Context | "city learning" OR "city ecosystem" OR "innovation ecosystem" OR "learning innovation" OR "learning" |
| | Intervention | "sources of innovation" OR "support learning" |
| AND | | |
| | Outcome | "Human Smart Cities" OR "City-to-City Learning" OR "City Learning" |

(Mengist et al., 2020). Classification of the basis for our search terms has been illustrated in Table 1. The search strings, as shown in Table 2, comprised of the following keywords: ("city learning" OR "city ecosystem" OR "innovation ecosystem" OR "learning innovation") AND ("support learning") AND ("within cities" OR "across cities" OR "cities") OR ("learning" AND "sources of innovation" AND "smart cities") OR "Human Smart Cities" OR "City-to-City Learning" OR "City Learning"). We did not include any restrictions for the date of publication in our search to avoid a narrow search.

### *Study Selection*

The selected research databases were searched based on the search strings. The studies found using the search keywords were screened. We removed duplicates and those studies that were not written in English from the selection base. Book reviews, abstract-only studies, and presentations were removed. Following the screening, we removed the studies that did not comply with the inclusion criteria. To satisfy the inclusion criteria, consideration of the concept of learning in cities for the development of cities through innovations was required. Studies that have been solely based on Machine Learning (ML) were excluded due to the drawback of ML models with regard to interdependent variables. Full-text studies were evaluated to determine if the study presented

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any framework for innovation in cities considering city learning. Studies that discussed innovation in cities considering city learning but did not present a framework design were excluded. Additionally, a backward and forward search was performed on eligible full-text studies. The final selection of studies resulted in studies as per the requirement of our RQ1 with frameworks for city development through innovations that have considered city learning. We analysed the frameworks identified from the outcome of answering RQ1 to find what has been addressed as learning in cities to answer our RQ2.

### *Selection Process*

The initial search identified 2139 studies from 11 databases (Figure 1). Screening the results yielded 1546 unique studies after the removal of duplicate entries and studies not in English. On manual examination of the retrieved titles and

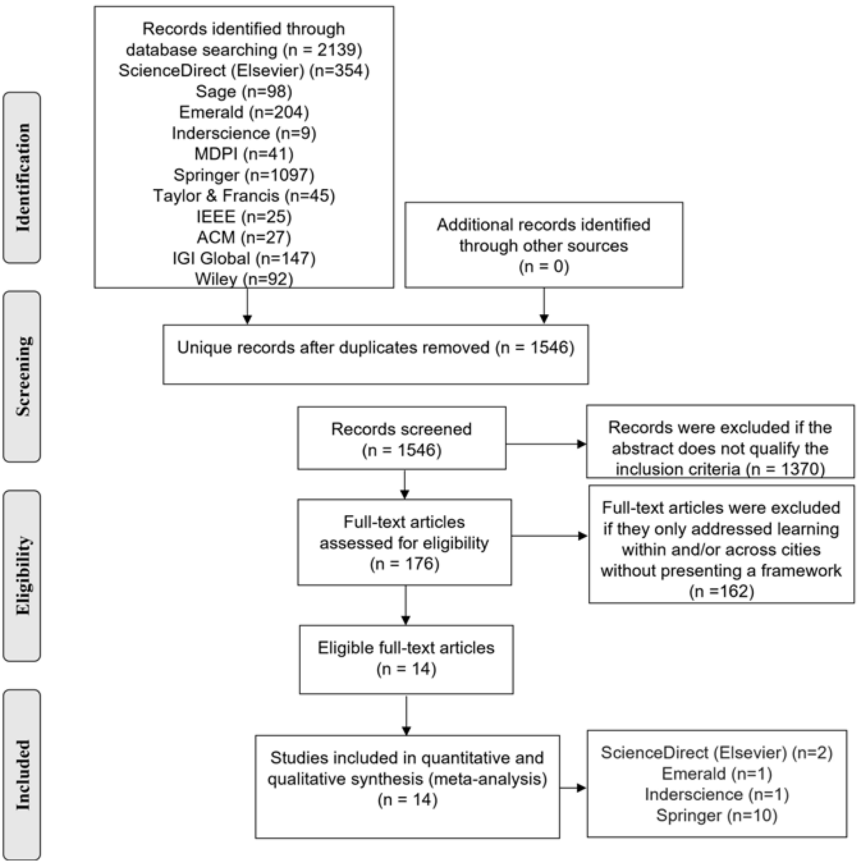


FIGURE 1 PRISMA (Preferred Reporting Items for Systemic Reviews and Meta-Analyses Moher et al. (2009)) flowchart for study selection

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their abstracts, 1370 out of the 1546 studies were excluded. To address our RQs, we set our inclusion criteria that the studies should have a) considered the development of human-centric cities through innovation, and b) presented frameworks for the development of human-centric cities considering city learning.

We analysed the full texts of the 176 studies to check if they satisfy the inclusion criteria and found that some of the studies refer to their contributions as a framework while others refer to them as models. As long as they satisfy our inclusion criteria, we have considered them and refer them broadly as frameworks. Based on such assessment of the full texts of the 176 studies, we found that 162 studies did not present a framework for developing cities through learning. Finally, we selected 14 studies based on our selection criteria.

## Results

### *Data Analysis*

Data from the final sample selection was extracted and classified. The following information was extracted for analysis: (1) general study information, including authors, their affiliations and publication year, (2) data source, (3) frameworks considering city learning, and (4) how learning in cities has been addressed.

### *Publication Pattern*

We carried out our search for the scoping review without any constraints for the time range of publications. Nevertheless, on analysis of the publication dates of the studies from the result of the scoping review, we find that the topic of city learning has gained focus in recent years. The year-wise distribution of the publications is shown in Figure 2. We find the earliest year for the publication of relevant studies to be 2006, with the highest number of studies published in 2016 and 2019. Selected studies are divided between peer-reviewed international conference proceeding publications and journals or book chapters, as shown in Figure 3.

### *Geographical Context and Interdisciplinarity*

The geographical context of cities also bears an impact on their developmental approaches. We extracted the name of the country of the affiliated institution for each author of the studies. For the affiliation country of every author, we assigned one point to its corresponding country. We conducted this procedure for all the authors of the selected studies. The points for each country are then

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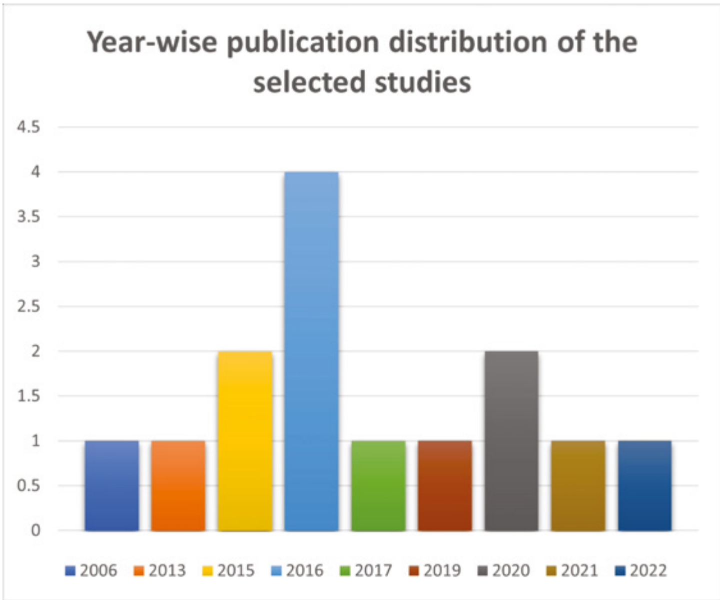


FIGURE 2 Year-wise distribution


FIGURE 3 Categories of publications



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summed to present the country-wise distribution of the author's affiliation, as shown in Figure 4.

We find that the studies presenting frameworks for city learning have been predominantly from authors with affiliations in European countries. Italy (n=6), Belgium (n=5) and Portugal (n=4) are the countries that are associated with a higher number of studies as compared to others. However, we find the cities which were considered in the studies belonged to Spain (Zygiaris, 2013), UK (Zygiaris, 2013; de Oliveira et al., 2015), Netherlands (Zygiaris, 2013), Portugal (de Oliveira et al., 2015), Italy (de Oliveira et al., 2015), Denmark (de Oliveira et al., 2015), Indonesia (Mayangsari and Novani, 2015), Belgium (Schuurman et al., 2016), South Africa (Preece, 2017), Brazil (Spinosa and Costa, 2020) and Canada (McKenna, 2021). We also explored the affiliated disciplines of the authors to assess the interdisciplinarity involved in these studies. We find the study interest in this topic is well spread over multiple disciplines, with Computer Science & Informatics having the highest contribution, followed by Engineering & Technology and Business Administration and Management as major contributors as shown in Figure 5.

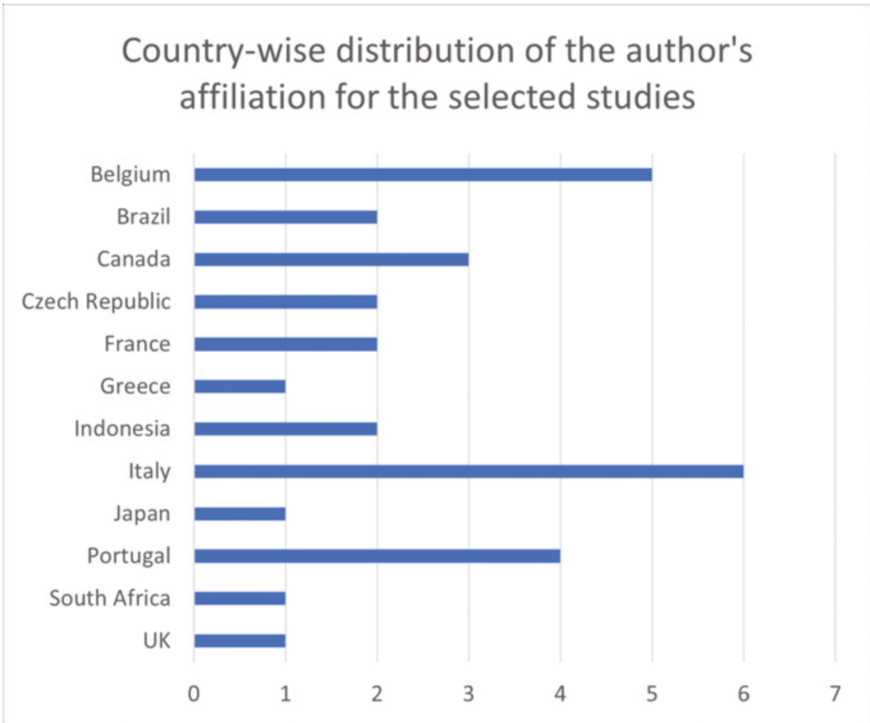


FIGURE 4 Country-wise distribution

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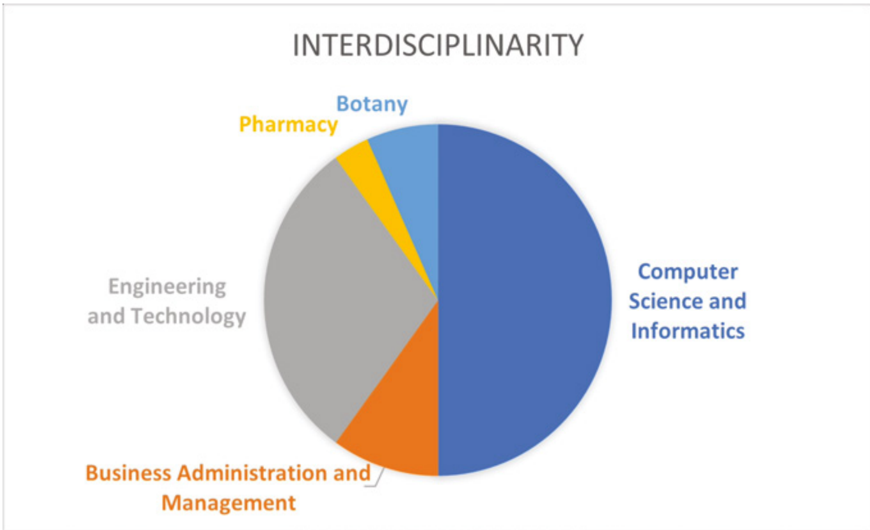


FIGURE 5 Interdisciplinarity of publications

***Study Characteristics***

The selected 14 studies have proposed conceptual frameworks for developing cities through innovation while considering city learning. The key insights of these frameworks are illustrated in Table 3.

Based on our understanding of city learning, knowledge production and sharing, and innovation ecosystems, we have framed 9 aspects to gain further qualitative insights into how learning and innovation in city ecosystems have been described in the selected 14 studies. We analysed the studies to check whether the frameworks presented in them address the following aspects: 1) city learning from within itself, 2) city learning across cities, 3) innovation through learning, 4) interaction between individuals, groups and institutions, 5) citizen-centric, 6) environmental sustainability, 7) use of digital technology, 8) utilisation of data, and 9) presents a validated standard framework. For this analysis, we have considered a point system where we assign one point to the corresponding aspect for each study if that aspect has been addressed in its framework and zero otherwise. Table 4 presents the analysis of the aspects that have been addressed in the frameworks in the context of learning and innovation in city ecosystems.

From Table 4, we see that the aspects of learning from within cities, cooperation between individuals, groups and institutions and citizen-centricity are present in all the frameworks identified through the scoping review, whereas learning across cities has been addressed only by two studies (Layte and Ravet,



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TABLE 3 Framework insights

| Index | Model insights |
| --- | --- |
| Layte and Ravet (2006) | Highlights the similarity between organisational learning and learning across territories/cities through the proposed model and the importance of leadership for learning in a city ecosystem |
| Zygiaris (2013) | Presents a Smart City Reference Model comprised of layers where learning is described to take place through the interactions and feedback of intermediate layers between the city and the innovation layers. |
| Mayangsari and Novani (2015) | Shows how the knowledge base of individuals, academic and business institutions are utilised through partnerships between public and private sectors supported by ICT aided platforms for value creation, resulting in the learning innovation cycle in Bandung smart city. |
| de Oliveira et al. (2015) | Highlights how Big Data analysis and citizen participation through social networks, open data platforms, using ICT solutions can lead to city innovation through learning. |
| de Oliveira (2016) | Presents an ICT-aided service platform for community collaboration and facilitation between administrators, citizens, academic and business institutions that can drive the innovation ecosystem through learning in a city. |
| McKenna (2016) | Institutions, humans integrated using context-aware technological infrastructures for collaborative innovations through Lifelong Learning. |
| Marsh et al. (2016) | Conceptualises the synchronisation of open data from sensors, service platforms and LL for innovation through social learning. |
| Schuurman et al. (2016) | Visualises top-level anatomy of an LL for driving innovation through learning. |
| Preece (2017) | Illustrates a framework describing Learning Cities as per the UNESCO UIL Conference Report for sustainable innovation. |
| Caputo et al. (2019) | Views learning in a city considering it as a Complex Adaptive System of citizens, physical infrastructures, contextual services and requirements through feedback adaptive cycle enabled by technology and data. |
| Spinosa and Costa (2020) | Innovation for humane and sustainable smart cities through learning is described in a framework based on a case-study comprising three levels of (i) main conceptual drivers, (ii) policy and strategic plan, and (iii) implementation. |

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TABLE 3 Framework insights (*cont.*)

| **Index** | **Model insights** |
|---|---|
| McKenna (2020) | Conceptualises learning in cities to be emerging from cognitive partnerships and their relationships through context-aware people and technologies. |
| McKenna (2021) | Illustrates community participation utilising learning and knowledge infrastructures. |
| Costales (2022) | Describes how learning of a city takes place at the micro, meso and macro levels wherein city represents an investor and a neoliberal seeker while learning as an organisation and a community. |

2006; de Oliveira et al., 2015). Furthermore, overall only one study (de Oliveira et al., 2015) has addressed more than 80%, and two studies (Zygiaris, 2013; Spinosa and Costa, 2020) have 70% of the considered aspects. We also found that none of the studies presented a validated standard framework.

We briefly discuss the frameworks in the context of learning and innovation in the city ecosystem as follows:

In Layte and Ravet (2006), the question of "Who learns" has been focused wherein learning communities have been considered to be at the heart of any territory or city learning, based on partnership with citizens, learning and professional communities, providers of education and learning as well as businesses. The proposed framework in Layte and Ravet (2006) is designed based on the similarities drawn between territory or city learning and organisational learning and highlights that leadership is crucial for learning because without a strategy and without knowing in which direction to move, no real learning can happen. The framework also incorporates the essence of learning from other organisations by accounting for learning from other territories or learning across cities. The study in Zygiaris (2013) presents a Smart City Reference Model, which represents the city ecosystem and describes learning in a city to take place through the intermediate layers of interactions and feedback. The model also accounts for environmental sustainability.

In Mayangsari and Novani (2015), a framework describing the value of a co-creation scheme of Bandung smart city multi-stakeholder was presented. This framework reflected how the city representatives act as enablers using an ICT platform for learning through the exchange of experiences and feedback, connecting the citizens, private institutions and knowledge providers,



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TABLE 4 Analysis of the aspects that have been addressed in the frameworks

| Publication | City learning from within itself | City learning across cities | Innovation through learning | Interaction between individuals, groups and institutions |
|---|---|---|---|---|
| Layte and Ravet (2006) | 1 | 1 | 1 | 1 |
| Zygiaris (2013) | 1 | 0 | 1 | 1 |
| Mayangsari and Novani (2015) | 1 | 0 | 1 | 1 |
| de Oliveira et al. (2015) | 1 | 1 | 1 | 1 |
| de Oliveira (2016) | 1 | 0 | 1 | 1 |
| McKenna (2016) | 1 | 0 | 1 | 1 |
| Marsh et al. (2016) | 1 | 0 | 1 | 1 |
| Schuurman et al. (2016) | 1 | 0 | 1 | 1 |
| Preece (2017) | 1 | 0 | 0 | 1 |
| Caputo et al. (2019) | 1 | 0 | 1 | 1 |
| Spinosa and Costa (2020) | 1 | 0 | 1 | 1 |
| McKenna (2020) | 1 | 0 | 1 | 1 |
| McKenna (2021) | 1 | 0 | 1 | 1 |
| Costales (2022) | 1 | 0 | 1 | 1 |
| **Percentage of studies addressing the aspect** | 100 | 14.28 | 92.86 | 100 |



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| Citizen-centric | Environmental sustainability | Use of Technology | Utilisation of Data | Validated standard framework | Percentage of aspects addressed in the study |
|---|---|---|---|---|---|
| 1 | 0 | 0 | 0 | 0 | 55.56 |
| 1 | 1 | 1 | 1 | 0 | 77.78 |
| 1 | 0 | 1 | 1 | 0 | 66.67 |
| 1 | 1 | 1 | 1 | 0 | 88.89 |
| 1 | 0 | 0 | 0 | 0 | 44.44 |
| 1 | 0 | 1 | 1 | 0 | 66.67 |
| 1 | 0 | 0 | 0 | 0 | 44.44 |
| 1 | 0 | 1 | 0 | 0 | 55.56 |
| 1 | 1 | 1 | 0 | 0 | 55.56 |
| 1 | 0 | 1 | 1 | 0 | 66.67 |
| 1 | 1 | 1 | 1 | 0 | 77.78 |
| 1 | 0 | 1 | 1 | 0 | 66.67 |
| 1 | 0 | 1 | 1 | 0 | 66.67 |
| 1 | 0 | 0 | 0 | 0 | 44.44 |
| 100 | 28.57 | 71.43 | 57.14 | 0 | |



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constituted by professionals providing the services in the city, the academic and research communities.

The MyN Platform described in de Oliveira et al. (2015), from the European MyNeighbourhood project, presented a layered view of the MyN Platform system component model, illustrating how Big Data analysis in conjunction with user participation can utilise ICT solutions for innovations through learning in the city ecosystem. This model accounts for adaptations from best practices of other cities and the environment while aiming to develop sustainable Human Smart Cities. The framework in de Oliveira (2016), in the context of developing Human Smart Cities, address learning in a city through a service platform for community collaboration and facilitation. de Oliveira (2016) highlights the interactions between the city government and the innovation ecosystem portrayed to be comprised of the citizens, academic/research and private institutions. In McKenna (2016), a conceptual framework was proposed for learning and innovation for smart cities based on the paradigm of Lifelong Learning wherein learning can take place anytime and anywhere within a city. It emphasises the use of emerging technologies for smarter relationships between technology, people and information to enable learning. A framework that describes how Learning Cities are built based on the Lifelong Learning paradigm as per the UNESCO UIL Conference Report of its first Learning Cities conference in Beijing is presented in Preece (2017).

The study in Schuurman et al. (2016) conducted an in-depth case study analysis of LeYLab, an LL in the context of an experimental fibre-to-the-home (FTTH) network in a neighbourhood in the City of Kortrijk, Belgium. An LL is referred to as an open innovation ecosystem in real-life environments where sustainable innovations are accomplished through iterative feedback processes generated by the participants (Schuurman et al., 2016). Based on the case study of LeYLab, a high-level conceptual anatomy of an LL was presented, illustrating how it can enable innovation in city neighbourhoods through learning. In Marsh et al. (2016), a very high-level model for innovation has been presented for developing Human Smart Cities, where technological and social innovations through LLs have been described as crucial alongside infrastructure and platform investments, network building, citizen empowerment and stakeholder engagement.

The framework presented in Caputo et al. (2019) describes innovation through learning in smart cities. This framework considers smart cities as Complex Adaptive Systems consisting of many elements, often called agents, that interact and adapt or learn. It emphasises that it is possible to efficiently understand the relational and transactional network in which the elements in a Smart City are engaged by analysing the Smart Technologies and Big Data. It

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has been argued that decision-makers can make citizen-centric innovations by learning this knowledge of Smart City elements' relational and transactional networks.

The study in Spinosa and Costa (2020) presents a framework which includes three levels for describing innovation for a humane and sustainable smart city through learning based on the studies of observations of the city of Curitiba in Brazil. The three levels of the framework are described as (i) main conceptual drivers, (ii) policy and strategic plan, and (iii) implementation. The conceptual framework for learning and creativity in smart cities proposed in McKenna (2020) presents an integral view of people, technologies and cities. It highlighted that the relationship between learning and partnerships between city elements can affect the comfort level of people living in the city while people and their needs can be addressed by accounting for their comfort through innovations. In McKenna (2021), an extended version of the conceptual framework in McKenna (2020) was presented which demonstrates the importance of learning and knowledge infrastructures for learning in smart cities.

Costales (2022) presents a high-level view of a city society stratified into three levels, the individual (micro), organisational (meso), and system (macro), that have different administrative and participatory powers. It also identifies two phenomena occurring at all points in the stratified city system: 1) sources of innovation (SOI) which refers to the perceptions of deficiencies which initiate the learning curve of innovation, and 2) loci of change (LOC) referring to the structures which allow the learning curve to disseminate through the system. The framework in Costales (2022) describes multi-level social innovation while considering the interdependencies of SOI and LOC that link to all three levels. This proposed multi-level social innovation framework discusses learning at the city level while considering the different perspectives of a city as a) a community learner, b) an investor, c) a neo-liberal seeker and d) an organisational learner. It highlights how policy implementation can be focused on enabling innovation through learning for the holistic development of human-centric Smart Cities.

## Discussion

We identified a large number of studies (1546) using the search terms that we have framed with the aim of answering our two research questions **RQ**s. Based on our inclusion and exclusion criteria, 14 studies were finally selected from the scoping review. The resulting selection of 14 studies were the studies that presented frameworks for the development of cities through innovations



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while considering learning from within and/or across cities. These frameworks answer our RQ1, which was focused on identifying existing frameworks that consider human-centric innovations in cities through city learning. We analysed the frameworks in these 14 studies to find what has been addressed as learning in cities to answer our RQ2.

To elaborate the answer to RQ2, we find that most of the frameworks were concerned with only smart cities and not cities in general. We find that a validated standard framework considering city learning from an ecosystem perspective for city development is missing. However, we find that cooperation between individuals, groups and institutions for ensuring citizen-centric city developments through innovations has received emphasis in all the frameworks. We find that the frameworks in (McKenna, 2016; Preece, 2017) and (Marsh et al., 2016; Schuurman et al., 2016) have incorporated the paradigms of Lifelong Learning and LLs, respectively, in their frameworks. Learning Cities relate to cities involved in Lifelong Learning that focus on the educational (school, adult and workplace) aspects of learning in cities (Power and Maclean, 2013). On the other hand, LLs are based on the open innovation model principles and involve citizens in co-design, co-creation and feedback ((Lucchesi and Rutkowski, 2021)). However, both approaches highlight the importance of interactions among the stakeholders in the system, and the frameworks identified through this study also emphasise the same. We find that citizen-centricity is at the heart of all the 14 frameworks, and the interactions among the city elements at individual, group or institutional levels are crucial to driving learning in cities for their development through contextual innovations.

We identified that technological solutions such as ICT platforms (de Oliveira et al., 2015) and Big Data analysis (Caputo et al., 2019; de Oliveira et al., 2015; Marsh et al., 2016) play a pivotal role in fostering these interactions for driving learning in cities as evidenced by Table 4. The frameworks in Costales (2022) and Layte and Ravet (2006) highlighted the correlation between learning in cities from within and across cities with that of organisational learning. We find that the frameworks described only in Layte and Ravet (2006) and de Oliveira et al. (2015) address learning across cities. The necessity of leadership and initiatives from governing institutions has been emphasised in Layte and Ravet (2006); Spinosa and Costa (2020). The results from the scoping review illustrate that there are multiple layers of interactions across individuals, groups of individuals, institutions, technology and the environment in a city ecosystem (Zygiaris, 2013; de Oliveira et al., 2015; Costales, 2022), leading to the emergent behaviour of the city (Caputo et al., 2019; McKenna, 2020).

We find that although learning in cities has been considered in the frameworks for developing cities, city learning while considering a city as an

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innovation ecosystem has not been addressed. We also find from the concepts of the Quadruple and Quintuple Helix Innovation Ecosystems (Carayannis and Campbell, 2010, 2021; Carayannis et al., 2022), that the helices are based on democracy and ecology where (1) co-evolution with democracy or knowledge democracy is essential for creation and evolution of knowledge and innovation, and (2) ecology, ecological sensitivity, and environmental protection needs to be considered as drivers for knowledge production and innovation development, apart from being a necessity for the survival of humanity. In line with these insights and based on the scoping review, three segments of the city ecosystem have been identified as drivers of city learning which are 1) humans, 2) technological systems and 3) the natural environment. The human segment illustrates knowledge flows through interactions between and across individual citizens, academic/business institutions and government/administrative bodies. These human interactions represent the human and societal aspects of a city.

Based on our analysis of this study, we hypothesise about the elements of a city and their interrelationships, from an ecosystem perspective, that can act as drivers of city learning through multilevel interactions and feedback and have presented a high-level conceptual model in Figure 6.

We have grouped the individual citizens, institutional bodies of local government/administration, academia and industry within a human-driven environment. We found from our analysis of the frameworks for city development that have considered the aspect of learning in cities that the natural environment can also act as a driver for innovation in a city ecosystem. We also found that due to the ubiquitous impacts of technology in city developments, technology can act as a driver for innovations in a city ecosystem, and other city ecosystems can also influence the innovation process of a city ecosystem. The internal elements of the city ecosystem are described in the large ellipse on the bottom part of the figure, labelled "City Ecosystem". The city ecosystem interacts with the external elements of the city ecosystem, such as other cities and possibly rural territories, and these are shown in the ellipse labelled "Other City Ecosystems". The conceptual model views the city as an ecosystem that acts as a large organisational entity whose emergent behaviour is determined by theinteractions of the relevant internal and external elements.

The helices of the Quadruple Helix model for innovation (Carayannis and Campbell, 2010), which are universities (U), industries (I), government bodies (G), and civil society representing the people (P) can be correlated with the elements within the human-driven environment of our conceptual model. Natural environment, which has been recognised as the fifth helix in the Quintuple Helix model for innovation (Carayannis and Campbell, 2021), is



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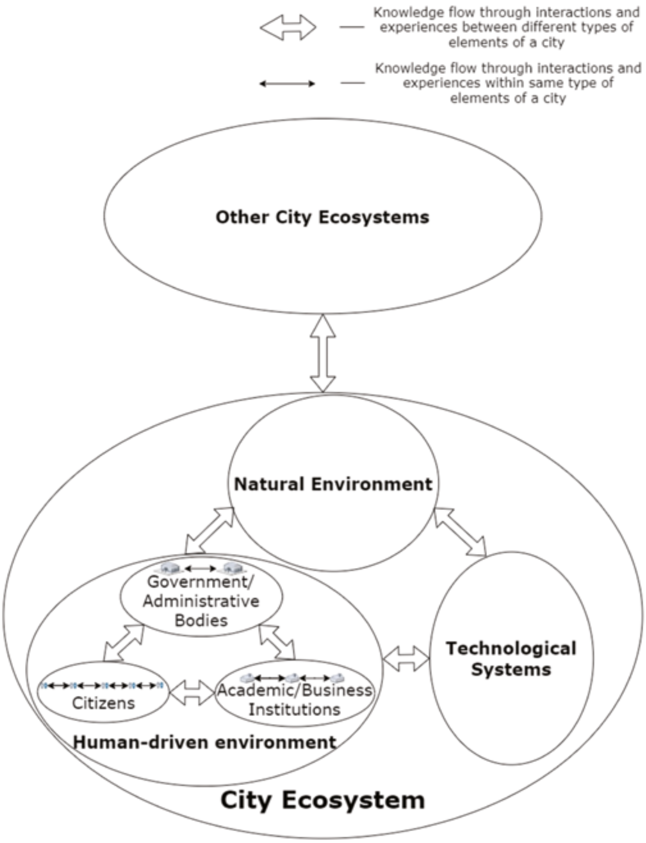


FIGURE 6 High-level conceptual model of interrelationships and interactions between city elements that can drive city learning from within and across cities

also represented in our high-level conceptual model as one of the elements that can drive innovations in a city ecosystem. However, even though our proposed conceptual model has been inspired by the insights from the theories of the Triple, Quadruple and Quintuple helices of innovation (Carayannis et al., 2022), it is contrasting to studies that aim to develop generic models for innovation, such as Cai (2022) wherein an enhanced model for innovation has been built upon the Triple, Quadruple and Quintuple helices for innovation. Our conceptual model, based on the analysis of this study, is limited to the context of representing the internal and external elements of a city and their interrelationships that can act as drivers of city learning as an innovation ecosystem through multilevel interactions and feedback.

The city ecosystem consists of several systems, which we have categorised as the human-driven environment, the natural environment and the

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technological systems. In this study, our focus has been on the human-driven environment, and therefore, we have not detailed the natural environment and the technological systems. There may be overlapping elements within all three. However, we focus on the interactions between the different environments. The human-driven environment represents the government and administrative bodies in a city, the various institutions such as the academic and private institutions, and most importantly, the citizens. The innovations and developments of a city are mostly driven by the initiatives and actions of the elements within a city's human-driven environment and the interactions among them. Of equal importance are the interactions between the human-driven environment with the technological systems and the natural environment. The technological systems may support the interactions and the elements in the human-driven environment within the city ecosystem. The actions of the citizens impact both the technological systems and the natural environment. Furthermore, human-induced impacts on the natural environment form an important aspect of the city ecosystem.

The socio-technical approaches arise from the interactions between humans and technological systems described through the knowledge flows through interactions between the corresponding segments. Both society and technological systems influence the natural environment, which in turn impacts them. The model also helps in viewing, from a high level, how a city can learn from within and across cities by sharing knowledge through interactions and feedback. Our proposed conceptual model helps us visualise the intra and inter-relationships, interactions and feedback between elements external and internal to a city, comprising the human, technological and environmental aspects, that can drive city learning as an innovation ecosystem. City learning contextual knowledge from its elements can help in the evolution of its emergent behaviour for sustainable human-centric city development. Supporting and harnessing this city learning can help in ensuring sustainable human-centric city development.

The model also shows that the city ecosystem does not act in isolation and interacts with other cities or elements of other cities. The ellipse labelled "Other City Ecosystems" represents the external elements with which a city ecosystem can interact. Such a high-level systemic view lets us perceive that a city ecosystem can be decomposed into multiple constituent/related (eco)systems which do not function in isolation. Impacts on a system could propagate impacts to other interrelated systems and vice-versa. These complex interactions result in the organic evolution of a city ecosystem. The impacts may not be linear and/or directly proportional. For example, what is good for the citizens may not suit the benefits of the business institutions, or what is good for one city ecosystem may not be good for another interrelated city ecosystem.



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What is good on the regional level can be a problem for a city in the region. Such a complex evolutionary dynamic entails that focus should be given to the interactions between different (eco)systems interrelated with a city ecosystem for its development through sustainable innovations. This assertion is also in line with the analysis in Leydesdorff and Smith (2022), which states that Quadruple, Quintuple, or higher-order of helices can be decomposed and recombined into interacting Triple helices, which could be considered as analogous to a city ecosystem. Furthermore, the interactions between the helices have been highlighted as more important than just the dimensions of the helices for sustainable learning and innovation in cities. These are relevant aspects to be considered to be able to support learning across cities. The city ecosystem view presented by the model can be considered generic and valid across all cities.

## Conclusion

In this study, we explored the existing literature regarding the development of cities with the aim of understanding the ecosystem view of a city and how learning in a city ecosystem can take place. To accomplish our aim, we conducted a scoping review to identify available frameworks for developing and innovating cities considering city learning. We then analysed how learning in cities has been addressed in those frameworks. We find that the attributes of the different elements in the city ecosystem need to be accounted for the sustainable human-centric development of cities. Such development necessitates that a city should be able to iteratively innovate through continuous learning of contextual knowledge about challenges and opportunities from the interactions and feedback among its elements.

Analysing the scoping review, we have found that the frameworks proposed in the studies are primarily conceptual models for the development of smart cities, and holistic consideration of urban development is missing. Although all the frameworks highlight the necessity of learning from within cities for developing the cities through innovations, learning across cities has been sparsely addressed. Furthermore, we have found that a validated standardised framework is not present for city learning that the stakeholders can use for city development through human-centric innovations and also utilise for assessing the impact of learning and providing feedback.

Based on the findings from the scoping review, we presented a high-level conceptual model to visualise the interrelationships and interactions among city elements that can drive city learning as an innovation ecosystem. The

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model highlights how a city, in general, can learn from within and across cities by incorporating the perspectives of the citizens, the society and the environment from an organisational viewpoint. Socio-technical and environmental sustainability aspects have been accounted for in the model through the interconnections for sharing knowledge through their interactions and feedback among the city elements within and across cities.

Learning contextual societal requirements, challenges and opportunities are integral to the process of innovation for sustainable human-centric development of cities. We observe that innovations complemented by the harmonious utilisation of ICT solutions are essential for coping with emerging city challenges and opportunities. A comprehensive understanding of city learning for driving cities as innovation ecosystems is a research challenge for researchers, ICT solution developers and urban policymakers.

The main limitations of our work are the search keywords and the online databases that were accessed during the scoping review. Our topic of interest is quite multi-disciplinary, and therefore, the databases that we have accessed, which are mainly related to Information Systems and ICT topics, did not provide a broad overview of the topic. This was evident from the results, e.g. the interdisciplinary chart that was provided as a part of the results of the study did not include relevant disciplines such as urban design. Furthermore, there is a selection bias due to the subjective selection of studies based on the manual analysis of abstracts and full-text studies.

The results of this study, in particular, the model that we have presented, provide a good start to enhance our research on the topic and help us identify areas where we could focus. Our future work would include an enhanced literature review by enhancing the choice of keywords and an expanded set of bibliographic search databases. We will continue validating our model as well as enhancing it by identifying the details of the different elements and their interactions, such as knowledge sharing and learning processes. Our future work would also focus on designing and validating a framework for effective design and utilisation of ICT solutions for supporting the learning process of city ecosystems.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this study.

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