How Cities Can Learn: Key Concepts, Role of ICT and Research Gaps

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Abstract. Learning in cities using the support of technological solutions, particularly with ICT focus, has remained a point of interest for researchers, propelled by the United Nations' Sustainable Development Goal 4, which is to ensure inclusive and equitable quality education and promote Lifelong Learning opportunities for all. Citizens of cities are considered learners who learn in cities through formal and informal education processes, enhanced by digital technology. Such Lifelong Learning considers that knowledge growth would enhance the functioning of cities leading to an increase in the smartness of the cities. However, even though learning in a city by its citizens has been considered, the role of the city in the learning process, and how a city itself as a system can learn (city learning) to meet the emerging challenges and opportunities have not received research focus. Understanding how a city learns along with its citizens is essential to support twin transitions in cities, to meet Sustainable Development Goals. We aim to explore how existing frameworks for city transformations, considering learning in cities, have addressed city learning. We conducted a scoping review to identify the relevant literature and analyse the main concepts and the role of ICT in this context. This study presents the main concepts in the literature and the research gaps in addressing city learning. We conclude that research is required to develop a conceptual framework for city learning through interactions and knowledge exchange among the elements and stakeholders of a city supported by ICT.

Keywords: City learning, Lifelong Learning, Twin Transitions, UN SDG, ICT support

1   Introduction

Smart learning ecosystems are often discussed in the context of smart cities, where the concept of smart city learning is used to describe people learning in the city or urban areas. A central notion of this is Lifelong Learning for citizens, anytime, anywhere and facilitated by digital technologies [1]. The concept of a Learning City has been identified as an important lever for achieving the United Nations' Sustainable Development Goals (SDGs), in particular, SDG 4: Ensuring inclusive and equitable quality education and promoting Lifelong Learning opportunities for all. UNESCO Global Network of Learning Cities (GNLC) defines a Learning City as one that "seeks to offer a range of Lifelong Learning opportunities through different actors, whether local governments, institutions or communities" [2]. Learning Cities has been primarily considered to consist of Lifelong Learning facilitated by technology, as the use of technology particularly ICT solutions enhance access to learning resources and learner engagement across the entire society. The UN's transforming education efforts identify the importance of public, and private partnerships and government collaboration in achieving the education goals and, indeed, the UN SDGs [3].

The conceptualisation of cities as learning territories describes cities or urban territories as spaces where people can learn [4]. The important connection between Lifelong Learning and cities considers the citizens in a city as students or ones that learn, and the city as the institution that facilitates and provides the means for the citizens to learn [5]. Citizens are also considered as the workers, and the city, as the workplace, where the workers can become more autonomous through education and learning. Lifelong Learning is clearly a central element in Learning Cities, where individuals learn while in the city, anytime and anywhere, facilitated by technology. This close connection between Lifelong Learning and the role that a city plays in facilitating and enhancing Lifelong Learning identifies cities as an important element in this context. The role of the city extends beyond being a space where people learn, but to one that facilitates learning and ensures the

appropriate infrastructure to support learning. As [5] highlights, bridging Lifelong Learning and cities is fundamental to Learning Cities.

Numerous transformations are required to achieve the UN SDGs; for example, energy reduction and decarbonisation and education equity to reach everyone. Many transitions also require a digital transition. Such simultaneous transitions are referred to as twin transitions [6]. Some of these transitions may conflict with one another. Moreover, there may be conflicts among the goals of different stakeholders, such as the private sector and the city or the needs of the citizens and the services the city administrators plan to provide to the citizens. It is of utmost importance that simultaneous transitions taking place in cities do not clash with one another; rather they reinforce one another. This calls for the cities to be attuned to the transitions and the alignment of governance activities and policy instruments. At the same time, the role of cities can also be seen as paradoxical in transitions [7], where the cities often have a challenging role in balancing the diverse transformations that take place within them. A top-down approach may not always be the best. A bottom-up approach through the engagement of the citizens, collaborations, and reacting and responding to the activities in the city can lead to more effective policy instruments [6]. There is a need for synergy among the citizens', institutions' and communities' needs and actions towards sustainable transitions.

The role of the city is central in the literature, and there are several perspectives of a city, such as a learning territory [4], an organisation [8], or an urban innovation ecosystem [9]. Cities have been described as learning innovation ecosystems [10], where the cities evolve and innovate themselves to meet the emerging needs of their citizens and institutions. Learning in cities has also been described as taking place at several levels, such as among individual citizens (similar to Lifelong Learning), at group or communities level, and at the institution level, where the city is the institution [11]. Do all these entities learn, where learning can be interpreted broadly as a change or leading to a change in the behaviour or a transition for the better? To ensure good twin transitions, it is important to consider a city as a system that consists of many entities that learn, and that the city as a system also learns. This has been the inspiration for our research.

A review of the literature on smart city learning, where the citizens learn through the use of technology, identified that there are numerous stakeholders that are involved in the learning process [1]. In addition to citizens, private and public sectors were identified as ones that play a role in learning. This is similar to the entities within a city, thus implying the significant role of the city itself in the learning process. Furthermore, the learning process generated knowledge, which no doubt would be beneficial for the different stakeholders. While there is research on Learning Cities and smart city learning, there is limited research that addresses cities as learning systems and how a city learns. In our work, we focus on understanding a city as a human-centric system that learns, evolves and innovates itself, to meet the needs of its citizens. We use the term "city learning", where we consider the city as a system that learns. We are inspired by the concept that cities are learning innovation ecosystems [10]. Considering the important relationship between Lifelong Learning and Learning City [5], we see the need for a better understanding of how a city can adapt to align itself better to the transitions taking place. A sustainable transition of cities requires twin transitions and alignment among them. Thus, ensuring inclusive and equitable education for all requires the city to align with the needs and transform in conjunction with the learning-related transformations.

The main objective of our research is to understand city learning, how learning is supported in existing frameworks for city transformations and how cities can evolve simultaneously with the different transitions in cities. To achieve this research objective, we have conducted a scoping review of the literature and analysed the relevant studies to understand how researchers consider cities and learning in cities. Our study identifies the research that proposes frameworks for learning in cities and how they have discussed the use of digital technologies and components which we have referred to as ICT in the rest of this study that support modern computing and enable people and organisations to interact digitally. The analysis also identifies the main concepts related to city learning, the different elements within the cities, how they interact, and the

different types of processes that are vital as a part of supporting learning in cities. This study also provides an overview of how ICT has been used in city learning. The outcomes of this study can be beneficial for stakeholders that provide services to achieve Learning Cities, but also for the city as an institution, which could better facilitate such initiatives, and learn, evolve and adapt itself in line with the learning and digital transformations.

The rest of this study is structured as follows: Section 2 describes the research methodology; Section 3 provides an overview of the studies selected in the scoping review; Section 4 provides an analysis of the studies structured in tabular format; Section 5 presents the key findings by identifying the main concepts, role of ICT regarding learning in cities and consequently the contextual research gaps; Section 6 provides a discussion and concludes the study.

2   Methods

In this study, our objective is to understand how city learning has been described in the literature and to obtain an overview of existing frameworks and ICT solutions that support city learning. The topic of interest overlaps multiple concepts and does not appear to have a comprehensive overview. Hence, we have selected the scoping review method to obtain an overview of the literature and to systematically map them.

A scoping review is a form of a literature review, which is appropriate if the topic has not yet been "comprehensively reviewed, or exhibits a large, complex, or heterogeneous nature" [12]. A scoping review is described as a means of assessing the potential size of the literature and a means to obtain an overview of the literature [13]. In a large and multi-disciplinary topic such as city learning, it is beneficial to narrow down and focus on the relevant literature before embarking on a systematic literature review. In such situations, a scoping review is considered a good approach to start, and the results of the scoping review could indicate if a systematic literature review needs to be conducted.

To conduct the scoping review, we have followed the stages described in the methodological framework for conducting a scoping review [14]. The stages are 1) identifying the research question; 2) identifying relevant studies; 3) study selection; 4) charting the data, and 5) collating, summarising and reporting the results. We have adopted this scoping review framework as a process with three main steps, which are described below:

- Step I - formulate the search criteria and set the inclusion and exclusion criteria for identifying relevant literature,
- Step II - analyse the studies to extract an overview and categorise and chart the findings based on the key characteristics identified,
- Step III - synthesise the findings to understand the existing concepts and gaps related to the objectives of the study for drawing conclusions.

These steps are illustrated in Fig. 1 and described in detail in the following subsections.

2.1   Step I - Searching

The first step is to search for the relevant body of literature for further analysis. To conduct this scoping review, we searched peer-reviewed online research databases of SpringerNature, ScienceDirect, IEEE, SAGE, ACM, Taylor & Francis, Emerald, Wiley, MDPI, Inderscience, and IGI Global. The search criteria were designed to explore the studies which presented frameworks that considered learning in cities for transforming cities through human-centric innovation and development. The search strings comprised of the
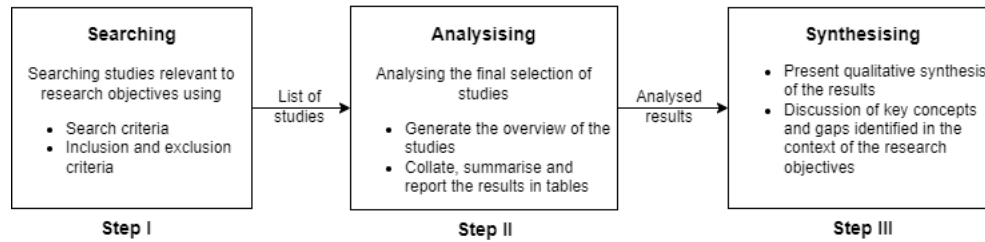
Fig. 1: Overview of the scoping review process

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"). To ensure a comprehensive search, no date restrictions were imposed. To ensure the relevance of the studies, we removed duplicates, non-English studies, book reviews, abstract-only studies, and presentations from our consideration.

We then applied our inclusion and exclusion criteria to select the relevant studies and included only those that had presented a framework as a means to support learning in cities. We excluded studies that discussed innovation in cities while considering learning in cities but did not present a framework for supporting it. Finally, we conducted a backward and forward search on eligible full-text studies.

2.2 Step II - Analysing

Our selection criteria in Step I yielded a final selection of studies that presented frameworks for city development through innovation for supporting learning in cities. In this second step, the full text of the studies was then analysed to identify the key characteristics related to city learning and the role of ICT. A qualitative analysis was conducted to identify the key characteristics of city learning. An inductive approach [15] was used for the qualitative analysis, to identify the key characteristics and to determine a framework for extracting and presenting the analysis of the studies. The results from this step are presented as textual summaries and in a tabular format.

2.3 Step III - Synthesising

In this step, we conducted an analysis of the results from Step II to understand how a city has been viewed in the selected studies, the contexts in which learning in cities has been discussed, the key elements of cities that are considered, what processes and interactions have been recognised and what has been the role of ICT in learning in cities. We categorised the characteristics according to the different concepts. Based on the results of this step, a discussion of the key concepts and gaps in addressing how cities can learn have been discussed highlighting the research requirements for addressing the phenomenon of how a city can learn as a system for transforming cities.

3 Results

According to the initial search of 11 databases, 2139 studies were found. Following the elimination of duplicate entries and non-English studies, 1546 unique studies were identified. Among these, 1370 were

excluded after a manual review of their titles and abstracts. The inclusion criteria were established for studies to ensure that they presented frameworks for innovation and development of human-centric cities while accounting for learning in cities. After analysing the full texts of the 176 studies, it was determined that some studies referred to their contributions as frameworks while others referred to them as models. However, such models were broadly considered as frameworks as long as they met the inclusion criteria. The assessment of the 176 studies revealed that 162 did not provide a framework for developing cities that considered learning in cities. Finally, 14 studies were selected based on the inclusion and exclusion criteria. We first briefly discuss the overview of each of the selected studies, and then we further analyse them to understand the prevalent concepts and research gaps regarding learning in cities.

3.1 Overview of the selected studies

According to the study conducted in [16], it is important to comprehend the interconnectedness of individual, community, organisational, and territorial learning in order to fully utilise the potential of e-Learning, which can lead to e-transformation and enhance the quality of education, training, human resources, and community development. The study, subscribing to the paradigms of Lifelong Learning and Lifewide Learning further, explains that due to the requirements of a knowledge economy and a learning society, education, training, and learning must be reevaluated to support lifelong and widespread learning. The term "knowledge economy" describes the way in which the economy is changing to produce value, goods, and services through the efforts of a new class of workers who specialise in knowledge-based tasks. Meanwhile, the concept of a "learning society" refers to a new type of relationship formed between citizens, organisations, businesses, government bodies, cultural institutions, and other entities, which leads to the formation of learning communities, cities, regions, and nations. While the knowledge economy emphasises the growth of financial capital, the learning society places a greater emphasis on the growth of social capital. The framework proposed in [16] incorporates insights from the city and organisational learning and emphasises the necessity of leadership in learning. In this context, the framework also incorporates the essence of learning from other organisations implying learning from other territories or across other cities.

In [17], smart cities are viewed as highly innovative ecosystems where extensive social interactions take place to generate economic value by acquiring, processing, and utilising information. In this study, a smart city reference model is introduced that represents the city ecosystem and takes into account the importance of environmental sustainability. The model in [17] also illustrates that learning in a city occurs through various layers of interaction and feedback. According to the study outlined in [18], a city can be thought of as a complex organisational system comprised of various elements and components that are interconnected through a series of interactions. Such an organisational system is viewed to be made up of individuals with different competencies, personal values and needs, where the stakeholders are defined as any group or individual that has the ability to affect or be affected by the organisation's objectives. The study [18] presents a framework for a co-creation scheme in Bandung smart city involving multiple stakeholders, which emphasises the importance of city representatives acting as enablers. Through the use of an ICT platform, this framework promotes learning through the exchange of experiences and feedback, connecting citizens, private institutions and knowledge providers, including professionals who provide services in the city, academic and research communities.

According to the study discussed in [19], the current implementation of smart cities, which is driven primarily by technology, is an important step. However, the smart cities concept ultimately falls short in terms of fully utilising the human dimension of cities. In this study, a platform to support a neighbourhood, the MyN Platform from the European MyNeighbourhood project, was presented, which provides a layered view of the platform and illustrates how Big Data analysis, in conjunction with user participation, can

utilise ICT solutions to promote innovation and learning within the city ecosystem. This model takes into account the environment and adaptations from best practices of other cities while aiming to create sustainable Human Smart Cities. The framework in [20] in the context of developing Human Smart Cities address learning in a city through a service platform for community collaboration and facilitation. The study highlights the interactions between the city government and the innovation ecosystem comprised of the citizen, academic/research and private institutions. It explains that technology-driven solutions for smart cities have often failed to engage citizens and public authorities. To address this issue, a service platform run by the city administration is suggested, which promotes the formation of virtual communities that can eventually migrate to the physical environment. The purpose of these communities shall be to collaborate and discover common interests and needs, which can then be used to co-design solutions with the government. The study [20] emphasises that citizen engagement is essential for building a trusted environment for co-creation.

The study in [21] has proposed a conceptual framework for innovation and learning in smart cities, which is based on the principles of Lifelong Learning. This framework emphasises the use of emerging technologies to establish smarter relationships between technology, people and information, to enable learning anytime and anywhere within a city. The proposed framework suggests that the technology-people-institution framework can be used as a basis for expanding and rethinking learning in smart cities. Specifically, [21] suggests that learning flows and relationships should be rethought to enable interactions and mutual learning between local government and educators and learners. The research work in [22] also presents a framework for building Learning Cities based on the Lifelong Learning paradigm, which is in line with the first Learning Cities conference report of UNESCO UIL in Beijing [23]. The study also notes that most literature on Learning Cities is practitioner or policy-based and is typically celebratory in nature.

According to the study in [24], Living Labs are open innovation ecosystems that enable sustainable innovations in real-life environments through iterative feedback processes generated by participants. The study conducted an in-depth case study analysis of LeYLab, a Living Lab in the context of an experimental fibre-to-the-home (FTTH) network in Kortrijk, Belgium, and presented a framework representing the high-level conceptual anatomy of Living Labs. Living Labs were found to enable innovation in city neighbourhoods through learning, and the local aspect of the city Living Lab fostered a strong sense of community building. It is highlighted in [24] that cities are well-suited for acting as Living Labs due to their direct connection to citizens, local private companies and organisations. The local aspect of city Living Labs can foster a strong sense of community among test users, which is less likely to occur in geographically dispersed Living Labs. A high-level model for developing Human Smart Cities was presented in [10], which included technological and social innovations through Living Labs, infrastructure and platform investments, network building, citizen empowerment, and stakeholder engagement. The study also proposed rethinking the Learning City to feature interactions between government, learners and educators in collaborative idea generation.

Smart cities have been viewed in [25] as spatial and temporal structures in which social and economic actors interact through institutions and technology to produce, exchange and co-create value. The study highlights that citizens need to be motivated to participate in the development of services where a holistic approach is necessary to understand how the relationships between agents affect the dynamics of a smart city over time. Systems thinking is suggested as the best approach for understanding the links and evolution of elements and relationships in the society of a city. The concept of innovation through learning in smart cities is described in a framework, which views cities as complex adaptive systems with numerous interacting and learning agents. This framework suggests that Smart Technologies and Big Data analysis can be used to effectively understand the network of relationships and transactions among elements in a smart city. The study also suggests that by learning this knowledge, decision-makers can create citizen-centric innovations.

The study in [26] proposes a framework for describing innovation for a humane and sustainable smart city based on observations of the city of Curitiba in Brazil. The framework consists of three levels, namely

the main conceptual drivers, policy and strategic plan, and implementation. The study considers the concept of a Humane and Sustainable Smart City (HSSC), which combines principles of urban development focused on citizens, smart city and sustainable development. It argues that the quadruple helix model (involving four types of stakeholders) is advantageous compared to the triple helix model, as it enhances innovation processes based on co-creation, emphasises open innovation dynamics, and designs solutions considering regional and local contexts. The study emphasises that knowledge creation, sharing and use processes are essential in a city, and finds that mobility and transport issues deeply influence urban planning processes. The main conclusions drawn in [26] regarding HSSCs are that there is a symbiosis between the urban innovation ecosystem and the HSSC implementation involving ICT. They also concluded that a positive innovation mindset and stakeholder participation in decision-making is important for organised civil society, and that co-creation and co-management provide stability and reduce vulnerability.

In [27], the concept of ambient creativity has been considered as "a more dynamic, adaptive, and evolving understanding of creativity, enabled by more aware people interacting among themselves and with more aware technologies. The conceptual framework for learning and creativity in smart cities proposed in [27] presents an integral view of people, technologies and cities. The study highlights that the relationship between learning and partnerships between the elements of a city can affect the comfort level of people living in the city, while people and their needs can be addressed by accounting for comfort through innovations. The study proposes a conceptual framework for learning and creativity in smart cities that offers a comprehensive perspective of people, technologies and cities. The study emphasises that partnerships between city elements and learning can impact the comfort of individuals residing in the city and that innovations that consider people's needs and comfort levels can improve their quality of life. In [28], an expanded version of the conceptual framework introduced in [27] was presented, emphasising the significance of learning and knowledge infrastructures for promoting learning in smart cities. It explores the underpinnings of Learning Cities, involving factors pertaining to privacy, security and trust. The study aims to facilitate urban infrastructure enhancements for learning, incorporating elements such as community participants as partners and learning from other cities (e.g through networks of cities) [28].

In [29], based on the analysis of the relevant literature, insights from social innovation, are introduced through four steps: (i) identifying the societal strata that give importance to innovation in the smart city literature; (ii) examining the interactions that foster innovation within these strata; (iii) discussing how these interactions can benefit from a social innovation perspective; and (iv) reconceptualising smart city by contextualising a multi-level model of social innovation within the urban context. The study presents a high-level view of the city society, which is stratified into three levels: the individual (micro), organisational (meso), and system (macro), which possess different administrative and participatory powers. The city is stratified at different levels, such as individuals, groups of individuals, and institutions, where two phenomena occur at all levels: sources of innovation (SOI) that refer to the perceptions of deficiencies that initiate the learning curve of innovation, and loci of change (LOC) that refer to the structures that enable the learning curve to disseminate through the system. The conceptual framework presented in [29] describes multi-level social innovation while considering the interdependencies of SOI and LOC that link to all three levels. This 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 focus on enabling innovation through learning for the holistic development of human-centric smart cities.

4 Analysis

We analysed the studies to extract the different key characteristics to understand what has been defined as learning in cities through frameworks for transforming cities through human-centric innovations and developments. The following key characteristics were identified: 1) how a city has been perceived, 2) how learning in a city has been addressed, 3) what elements of a city have been considered for learning in cities, 4) what processes have been considered for learning in cities, 5) the key interactions in the processes, 6) the role played by ICT to support learning, and 7) the context of the study. The results are presented in Table 1.

In our analysis, we consider ICT as the infrastructure and components that support modern computing, encompassing all networking devices, systems, applications and components that enable people and organisations to interact digitally. This includes traditional technologies such as landline telephones, radio and television, as well as advanced technologies such as artificial intelligence and robotics.

After synthesising the information provided in Table 1, we identified the main concepts about cities and the processes and interactions regarding learning in cities. We categorised the synthesised information for understanding the following main concepts: a) how a city is perceived, b) key elements of a city, c) processes considered for learning in cities to drive innovations, d) key interactions, and e) utilisation of ICT support. The synthesis identified how the main concepts were addressed in the different studies and this is presented in Table 2.

Study	What has been considered a city	How learning is addressed	Entities considered	Processes involved	Interactions in focus	ICT usage to support learning	Application contexts
[16]	Cities have been considered Learning Territories while viewing from an organisational perspective	Considers learning communities are at the heart of the idea of a learning territory (city), where a city can learn like an organisation by linking individual, community, organisational and territorial learning through the process of organisational learning	* Individuals * Professionals * Groups of individuals like associations, clubs or networks and the society of a city * Leadership from individuals, professionals or groups * Other cities	* Knowledge creation * Formal learning * Informal learning	Interactions between * Citizens * Learning and professional communities * Education providers * Businesses	Utilisation of knowledge, information, and learning technologies (KILT) for documentation, assessment, and support of technology-aided transformations of education, training, and human resource development	In the context of Lifelong Learning, Lifewide learning, Organisational learning
[17]	Has considered smart cities as IT based innovative urban ecosystems	Presents a layered conceptual reference model of a city for technology-enabled innovation through learning	* Urban resources * Infrastructures, utilities * Services * Stakeholders as per triple-helix framework	* Information acquisition, processing and its utilisation for economic value creation * Sustainability assessment through KPI evaluations	* Social interactions and feedback	ICT solutions for interconnections between entities	Driving innovation by increasing IT based smartness of cities
[18]	A city has been seen as a complex system of systems where a set of elements or components are tied together through sets of interactions having competing power and interest of stakeholders, any group or individual, who can be affected by the systems and a smart city expanded this view to be considered an innovation ecosystem enabling collaborations that integrate new technologies like ICT with the city	Proposed a model for Bandung city for the stakeholders to learn the city characteristics, reflect on the vision decided by the city representatives, and provide the appropriate scientific reasons for deploying the projects	* Enablers: City representatives * Utilisers: Firms * Providers: Educational institutions and professional private sectors * Users: Citizens and visitors	* Collection of information * Analysis of qualitative information for policy development and implementation	Interactions and feedback between stakeholders (enablers, utilisers, providers and users)	Platform supporting interactions between stakeholders for value creation through knowledge sharing	Multi-stakeholder co-creation in Bandung smart city
[19]	Discusses Human Smart City (HSC) 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 "wicked" societal problems	Models the Human Smart City the concept as an improvement of the smart city, focusing on creating a healthier and happier environment for citizens which requires a great number of people to change their mindsets and behaviour through learning	* Citizens * Communities * NGOs * Enterprises * Universities * Public and private stakeholders, such as Finance * Other cities	City government implements and supports an ecosystem of urban innovation for the co-design and co-production of social and technological innovation services and processes with citizen participation through * Urban living labs * Workshops and meetings * Service Platforms	Learning from experiences from * Individuals * Communities * Public and private bodies * Other cities	Service platform for interconnection between individuals and other cities for knowledge sharing	MyNeighbourhood Platform in the context of living labs and co-design activities within pilot cases for Human Smart Cities Network
[20]	HSC referred to as an urban living lab innovation ecosystem, which applies user-driven open innovation methodologies and tools to codesign and coproduction of social and technological innovation services and processes, by citizens and governments together	Models Human Smart Cities for enabling codesign and coproduction of social and technological innovation services and processes	* Public administrators * Citizens and civic organisations * Business organisations, academic and research institutions	Co-design through interactive, dialogic, and collaborative processes	Interactions between individuals (citizens) and other stakeholders	Service platform for community collaborations and facilitations	In the context of urban living labs for Human Smart Cities Network
[21]	Views smart cities as Learning Cities as per the UNESCO definition [23] where "human and other resources to promote inclusive learning from basic-to-higher education; revitalises learning in families and communities; facilitates the use of modern learning technologies; enhances quality in learning; and nurtures a culture of learning throughout life"	Maps people, technology and information through the perspective of Learning Cities for driving innovation in smart cities through learning by illustrating what is possible in a real-world, local community	* Technology * Educators/learners * Local government	Engaging people locally in the early codesign processes for emergent collaborative technological solutions for smart cities where learning is integrated with aware-enabled technology across all community sectors	Interactions between * People * Technology * Information	Social radio tool for creating contextual awareness for driving innovation through learning and collaboration of the entities	Rethinking of smart city learning in terms of technology–people–institutions conceptualisation [30] of a smart city
[10]	Refers to the concept of HSC, originated from the EU PERIPHĒRIA project, grounded on complementary "softer" features of "smartness" such as clarity of vision, citizen empowerment, and participation in sustainably transforming cities through learning	Models transition towards HSC using existing SC visions for innovation and city strategies utilising smart grids and sensors, open data, service apps and platforms and community living labs	* Citizens * Government	* Planning vision and initiation through leadership * Network building * Citizen empowerment * Stakeholder engagement * Technological innovations * Social Innovations	Interactions between * People * Government * Technology	* Smart grids and Sensors * Service Apps and Platforms * Open Data	In the context of Europe 2020, HSC

Table 1: Extracted results from the overview of the selected studies: key characteristics

Study	What has been considered a city	How learning is addressed	Entities considered	Processes involved	Interactions in focus	ICT usage to support learning	Application contexts
[24]	A city is illustrated as a suitable enabler for Living Lab activities by virtue of having a direct link to the citizens (potential users), local private companies (potential utilisers) and local organisations (potential providers)	Models the anatomy of Living Labs in cities for driving innovation through learning	* Citizens (potential test users) * Local private companies (potential utilisers) * Local organisations (potential providers) * Researchers	Innovation processes of Living Labs, which by the virtue of being open innovation systems, foster different knowledge transfers among the participating entities	Interactions between * Utilisers * Users * Providers * Researchers	* Smart devices given to the users * Mobile or fixed networks rolled out in a given environment * Sensor network	A case study analysis of LeYLab, a Living Lab based upon an experimental fibre-to-the-home (FTTH) network in a neighbourhood in the City of Kortrijk, Belgium
[22]	Views a city as a Learning City as per the UNESCO definition [23]	Illustrates the framework presented in UNESCO UIL Conference Report of its first Learning Cities conference in Beijing to explain how Learning Cities are built	* Individuals * Group of individuals and Institutions * Government	* Developing a plan for becoming a Learning City * Creating a coordinated structure involving all stakeholders * Initiating and maintaining the process with celebratory events * Ensuring that all citizens have access to learning * Establishing a process of monitoring and evaluation * Ensuring sustainable funding	Dialogue between people and organisations through complex interactions	Digital technologies to support sharing of data	In the context of city strategies for UNESCO Life Long Learning
[25]	An ecosystem view of smart city as complex adaptive systems have been considered where a smart city can be considered a complex system of users, services and technologies linked to ensure a shared satisfaction	Modelled smart city in the complex adaptive system (CAS) view that can adapt itself utilising the support offered by technologies (Smart Technologies) to respond to citizens' behaviours and expectations (using Big Data)	* Customers * Industry * Developer	* Citizen motivation and engagement * Participation * Feedback * Adaptation	Interactions between * Social actors * Economic actors	* Smart devices * Big Data	In the smart city context discusses the importance for a city to support innovations, the use of new technology, communication (people, services, private and public organisations from different city sectors), citizens' engagement and knowledge development to create a supportive synergistic environment
[26]	Considered the concept of a Humane and sustainable smart city (HSSC) that merges concepts from urban development focused on citizens, smart city, and sustainable development principles	Presents a descriptive framework for transforming Curitiba into an HSSC by incorporating various concepts and models for adapting development approaches, and carrying out numerous initiatives	As per Quadruple Helix *Civil society * Government bodies * Private Institutions/ Industry * Academia * Natural environment	Open innovation through * Codesign * Cocreation	Close interaction between * Local community * Government bodies * Private institutions * Academia involved in the innovation process	* Teaching technologies in education * QR codes and smart devices to share information	In the context of exploring the harmonised approach between Curitiba's urban innovation ecosystem and the city's endeavours to convert into an HSSC
[27]	Considers the smart cities dynamic as of people-technologies-cities while holistically viewing smart cities and Learning Cities as smart urban environments/regions	Develops a conceptual framework for learning and creativity in smart cities, incorporating the notion of comfort	* People * Technologies * Public and private institutions	* Extending emotion/affect (e.g., the experience of comfort) * Sharing information on people's behaviour patterns * Partnerships, and relationships, extending to affective, social and other dimensions	Interactions between * Aware applications and aware people that influence learning * City infrastructures and technologies * And across people and institutions	* Aware technologies that can offer is to assist in citizen/visitor education and their awareness	Explores the challenge for learning and creativity, in an "intelligent era" in the context of urban life, smart cities, and Learning Cities
[28]	Considers Learning City as a fundamental component of smart cities aligned to the idea in [30], where having the focus on the human dimension, fostering creativity plays a crucial role in the development of smart cities, with a significant focus on the essential roles of individuals, education, learning, and knowledge	Presents a model based on the interactive dynamic of people— technologies—cities where learning is explored through the proxy of community participation in relation to learning infrastructures and knowledge and data infrastructures in smart cities contributing to emergent understandings of Learning Cities, involving factors pertaining to privacy, security, and trust	* People * Knowledge & data infrastructures * Learning infrastructures	* Community participation * Formal learning * Informal learning	Interactions between * People and Knowledge and data infrastructures * People and learning infrastructures	* Smart devices such as sensors and IoT devices * Social media	In the context of developing and extending understandings of the importance of learning infrastructures and knowledge infrastructures in smart cities and utilisation of interactive, aware and adaptive digital and data infrastructures for Lifelong and Lifewide learning
[29]	Considers city as an ecosystem from an organisational perspective while examining a stratified view of society to understand how the stratas give prominence to innovation in a smart city literature	Conceptualises a multi-level model of social innovation through learning within the urban context for smart cities	* Individuals at micro level * Organisations at meso level * City as a system at macro level	Social innovation propelled by Sources of Innovation (SOI) at Loci of Change (LOC)	Interactions between the micro, meso and macro levels	Technological tools to ensure efficient collaboration among the city's organisational actors by collaboration within and across the stratas	In the context of understanding stratified view of the society having the individual (micro), organisational (meso), and system (macro) levels that promote innovation through learning by taking a systems approach

Table 1: Extracted results from the overview of the selected studies: key characteristics (continued)

Main concepts	Overview of concepts in the studies	Relevant studies
Broad perspective through which city is viewed	Learning territory	[16],[21],[24],[22],[28]
	Organisation	[16],[29]
	Complex adaptive system	[18],[25]
	Urban innovation ecosystem	[17], [20],[25],[27],[29]
	Smart city	[19],[10],[25],[26],[28]
Elements of a city	Individuals	[16],[17],[18],[19],[20],[21],[10], [24],[22],[25],[26],[27],[28],[29]
	Group of individuals and institutions	[16],[17], [18],[19], [20], [21], [10], [24], [22], [25],[26], [27], [29]
	Government institutions	[17], [18], [19],[20], [21], [10], [24], [22],[26], [27], [29]
	Academic and research institutions	[17], [18], [19], [20], [21], [24], [22],[26], [29]
	Private organisations and industries	[16], [17], [18], [19], [20], [24], [22], [25],[26], [29]
	Other Cities	[16], [19]
	Technology	[17], [21], [10], [27], [28]
	Natural environment	[26]
Processes crucial for city innovations through learning	Planning with leadership	[16], [10], [22]
	Motivation and participation of citizens	[16], [19], [20], [21], [10], [24], [22], [25], [26], [27], [28], [29]
	Engagement and empowerment of citizens	[19], [20], [21], [10], [24], [22], [25], [26], [27], [28], [29]
	Information collection	[16], [17], [18], [20], [21], [24], [22], [26], [27], [28], [29]
	Sharing ideas and codesign	[19], [20], [21], [10], [24], [22], [26], [27], [28], [29]
	Reflecting on experience and information analysis	[16], [17], [18], [19], [20], [21], [10], [24], [22], [26], [27], [28], [29]
	Providing feedback	[16], [17], [18], [19], [20], [21], [24], [22], [25], [26], [27], [28], [29]
Interactions between the elements of a city	Formal interactions through education	[16],[18],[21],[22], [26], [27], [28], [29]
	Interactions in social settings	[16], [17], [18], [19], [20], [21], [10], [24], [22], [26], [27], [28], [29]
ICT support for learning in cities	Formal education, training for human resource development	[16], [18],[21],[22], [26], [27], [28], [29]
	Social connectivity	[16], [19], [20], [21], [10], [24], [25], [28], [29]
	Communication between different elements of a city	[16],[17], [18] [19], [20], [21], [10], [24],[22], [25], [26], [27], [28], [29]
	Sensing, collection and sharing of information	[16], [18], [19], [20], [21], [10], [24], [22], [25], [26], [28], [29]

Table 2: **Extraction of main concepts from the synthesis of the results**

5 Key Findings

In this section, we present the synthesis of the analysis of the studies. We have identified the key concepts from the studies, how ICT have been used to support city learning and some research gaps, which are presented in the following sub-sections.

5.1 Main concepts

We have found that the selected studies have considered cities from different perspectives of a) learning territories, b) organisations, c) complex adaptive systems, d) urban innovation ecosystems and e) smart city.

However, these are not mutually exclusive perspectives. The urban innovation ecosystem, complex adaptive systems and organisational perspectives take a system's view of a city. A city can be referred to as a system of systems, which comprises diverse systems necessary for the functioning of a city, such as the service systems providing citizens with access to essential services like water, food, health, electricity, and transport. It has also been argued that viewing a city through a system's perspective is the best approach for understanding the links and evolutions of elements and relationships in society, which can drive human-centric innovations and development through learning in cities. Learning territories and smart cities are the labels for city types that have evolved in recent times. A Learning City (territory) has been illustrated as the core of a smart city, and any city or smart city can be viewed through the systems approach as a large-scale complex self-adaptive organisation.

Citizens are the central entities in cities, highlighted in all the frameworks in the selected studies. We find that the human component of cities comprises citizens associated with different levels of powers, such as civic bodies/NGOs, and public/private organisations are represented by groups of individuals from the citizens of a city but with different levels of authoritative powers based on the hierarchies of city society. From the extracted results and their synthesis, we find that technology-aided service systems and environmental parameters impact the process of learning and transformation in cities. In addition to the use of the Triple helix framework, the Quadruple Helix framework for innovation comprising representatives from public authorities, industry, academia and citizens has also been considered along with the natural environment to describe city interactions while considering it a knowledge economy. This approach reflects the Quintuple helix framework view. We find that due to the ubiquitousness of technology in a city, it has been considered an entity rather than just a facilitator. As in the case of organisations, it has been highlighted that other cities also can impact the transformation process by sharing their contextual knowledge from their prior experiences. This relates to the fact that a city can learn from both within and across cities. Apart from the human components, we find technology, the natural environment and other cities as the key elements of a city that can shape the evolution of a city through interactions and knowledge exchange.

We have identified from the synthesis of the results that leadership is a special kind of human action that is crucial for driving innovation through learning. Leadership, whether by individuals or by public/private organisations, is required to plan, initiate and monitor the processes. As implied from the importance of citizens of a city, the transformations of a city need to be done by having citizens onboard for the transformative processes. Thereby, the empowerment of citizens is crucial to ensure their motivation and engagement to drive learning in cities for contextual innovation and development. Information communication and assessment processes are found to form the basis for driving innovation by generating new knowledge. Such processes can enable co-design and co-development through sharing of ideas, collection of information, reflective analysis of available information and feedback. We find that the interactions for these information transfers have been considered to take place broadly in formal education and informal social interaction settings.

5.2 Use of ICT

We have found that the use of ICT solutions has been discussed in the selected studies as tools to enable more interactive and intuitive teaching-learning processes in education, personnel training and human resource development scenarios following the notion of Lifelong Learning. ICT support has been found to be key for interactive presentations of contents, sharing of data, documentation and assessment of the outcomes of the teaching-learning processes. These tools comprising ICT components, such as digital learning platforms and smart devices, have been focused on ensuring better learning outcomes for the learners. ICT solutions have also been discussed for communication between the learning entities in a city to enable Lifelong Learning

for getting transformed into Learning Cities. The communication between the learning entities has been addressed through the use of social media, smart device networks, data-sharing platforms and mobile or fixed networks of communications. Upon synthesising the results from the frameworks, we find that ICT-enabled service platforms are also discussed as crucial tools for supporting collaboration between stakeholders of a service in a system by enabling interconnections between them and sharing of knowledge. We find that the utilisation of ICT in the context of learning in cities has been broadly for teaching aids, communication and information sharing, and service platforms. However, we find that the literature did not address how a city as a system can be supported by ICT.

5.3   Research gaps in addressing how cities can learn

Based on the synthesis of the analysed results, we find that even though the selected studies present frameworks for transforming cities through innovations and development while accounting for learning in cities, how a city as a system can learn has not been addressed. For sustainable twin transformations, viewing cities as complete systems as per the systems thinking approach has been advocated for understanding the links and evolutions of elements and relationships in the societies of the cities. The concept of Learning Cities has evolved to drive transformations in cities through human resource development through informal and formal education as per the paradigms of Lifelong Learning and Lifewide Learning. Such human resource development can help bring about positive changes in a city's society in the long run and drive human-centric transformations. However, even though individuals are the centre of such learning, how that learning can be utilised at a given time for addressing any specific emerging challenge or opportunity, and to ensure continuous contextual innovation and development of cities and how a city as a system can learn needs to be addressed. Co-design and co-development activities through approaches such as Living Labs have been suggested for addressing emerging challenges/opportunities in a city through collaboration between its stakeholders. However, a generic framework following the Living Lab approach that can continuously enable city learning as a system from within itself and across cities is missing.

It has been discussed in the previous subsection that a city can be viewed through the systems approach as a large-scale complex self-adaptive organisation where learning can take place at individual, group and system levels. This resemblance opens up the scope for exploring the process of how organisations learn from within themselves and across organisations, to better address the city as a system that learns from within itself and across cities. There is a resemblance between the learning taking place in the different levels of a city and the mechanism of learning described in some organisational learning frameworks, such as the 4I [31] and ICULT [32] frameworks, where the learning at the organisational level emerges through the learnings from interactions and feedback at the individual, group and organisational levels. Such learning models have not been explored in the existing frameworks for city transformations.

We observed from the synthesis of the results that citizen participation, motivation and engagement have been mandated as crucial for empowering citizens and driving transformations in cities through learning from their interactions, ideas, knowledge from their experiences and reflective analyses and feedback. To ensure citizen engagement, we also found that citizens' privacy and trust concerns need to be accounted for. From the results, we found that apart from supporting formal education and human resource development training, ICT solutions, such as digital platforms, have been suggested for ensuring learning to drive contextual city transformations through co-design and co-development activities, where the platforms can support the collection of information using smart devices, Big Data, communication and sharing of information between stakeholders. However, there is a lack of emphasis on how ICT solutions can assist in the reflective analysis of the stakeholders. The frameworks presented in the selected studies in this review also do not provide a mechanism through which ICT solutions can instil stakeholders' trust, by accounting for

citizens' privacy concerns, and ensure citizen empowerment through citizen participation, motivation and engagement.

The frameworks presented in the selected studies are conceptual frameworks, and they do not present a working model which can help in monitoring and assessing the evolution of the smartness of a city. An ICT-aided generic framework is missing that can support a city to learn from within itself and across cities with a systems view for a city considering all its service systems under one hood so that how innovations to one service system affect other interrelated systems in a city can be monitored and assessed transparently by all its stakeholders.

6 Conclusion

This study focuses on the role of the city as a system that learns and the relevance of that for achieving the UN SDGs, particularly SDG 4, for inclusive and equitable Lifelong Learning opportunities for all. Cities are central to achieving sustainable digital transitions supporting education and Lifelong Learning. We found that the notions of a Learning City and learning in a city do not always reflect how a city as a system can learn and adapt to the needs of the citizens. Even though Learning Cities focus on Lifelong Learning using technology, how that learning can be utilised at any time to address emerging challenges or opportunities, and how a city can best adapt to emerging needs is unclear. There is a need to address how a city as a system can learn.

This study contributes to understanding the city as a system and the main concepts related to city learning. The objective of this study has been to comprehensively understand from existing frameworks for innovation and development of cities what a city can learn to drive human-centric city transformations and how ICT can support city learning. To accomplish our aim, we conducted a scoping review. We analysed the studies selected in the review to understand the existing perspectives through which a city has been viewed regarding learning in cities and how ICT have been used to support learning in cities. The results of the analysis were synthesised to identify the main concepts regarding learning in cities and the research gaps in addressing how a city as a system can learn. The results of this study illustrate how a city as a system resembles a large-scale complex organisation that it can learn through individual, group and system levels from within itself and across cities.

The results highlight that mere access to ICT-enabled communication and information transfer between stakeholders is insufficient for cities to learn from within itself and across cities. Ensuring citizen participation, motivation, and engagement are essential for empowering citizens and driving human-centric transformations through learning from their interactions, ideas, knowledge, experiences and reflective analyses and feedback. A rethinking of the concept of Learning Cities is required to take a holistic view of a city as a system that learns, evolves and adapts to meet the emerging needs of its citizens and to align with and support the numerous transitions taking place in cities. There is a need for developing a generic framework that utilises the potential of ICT solutions to support city learning. This study contributes to the understanding of how a city as a large-scale complex organisation system can learn.

The main challenge in conducting the scoping review was identifying the relevant databases to search and to define relevant search, inclusion and exclusion criteria. This is mainly due to the multi-disciplinarity of the subject. Moreover, the review was inspired by viewing cities as innovation ecosystems that evolve and learn. Hence, the search criteria were relevant to that context and did not include the terms Lifelong Learning and sustainable transitions. This may be considered a weakness of the study.

One direction of our future work would be to enhance the search criteria and conduct a systematic literature review. Based on the results of this study, our future research will aim to develop a conceptual framework

for city learning, which will consider the city with several elements and stakeholders that interact, where information, knowledge and experiences are shared, and ICT supports the learning processes. The results from this study can also be used by researchers, policymakers and private service providers in the context of city learning from within itself and across cities that can drive collaborative, holistic city transformations through sustainable citizen-centric innovations.

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