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Key elements, processes and research gaps in city learning as an innovation ecosystem: A scoping review

Pradipta Banerjee, Sobah Abbas Petersen

Department of Computer Science, Norwegian University of Science and Technology, Trondheim 7034, Norway
{pradipta.banerjee,sap}@ntnu.no

Abstract. Learning in cities with the support of Information and Communication Technologies has been a point of interest for researchers. The main objective of this study is to understand city learning, or learning in cities, where cities are considered learning and innovation ecosystems. This study explores how learning in cities is supported by existing frameworks for city transformations and identifies the key elements and processes for city learning as an innovation ecosystem. The study defines city learning as a process involving citizens, institutions, and communities and considers the city to be a system that can learn and innovate. The study conducts a scoping review of relevant literature and a qualitative analysis of the key characteristics of the frameworks, such as how they view the city, how they address learning, what interactions they focus on, and how they use Information and Communication Technology. The study identifies the main concepts, the key elements and processes in city learning and the current research gaps. The key elements and interactions are then described with reference to a conceptual model of the city ecosystem, and the elements are mapped with required processes to drive city learning. The findings from this study can help ascertain how a city can learn as an innovation ecosystem and can be beneficial for achieving twin transitions of the city and lifelong learning.

Keywords: City learning, Lifelong Learning, Twin Transitions, City Ecosystem, Innovation Ecosystem.

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 (UN 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 Information and Communication Technology (ICT) solutions, enhances access to learning resources and learner engagement across the entire society. The UN's efforts in transforming education identify the importance of public and private partnerships and government collaboration in achieving the education goals and, indeed, the UN SDGs [3].

Learning cities is based on conceptualising cities as learning territories that describe cities or urban territories as spaces where people can learn [4]. The important connection between Lifelong Learning and cities is that the citizens in a city are considered students or ones who learn, and the city is considered the institution that facilitates and provides the means for the citizens to learn [5]. Citizens are also considered workers, and the city is perceived as the workplace where workers can become more autonomous through education and learning. Lifelong Learning is 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 a city's role in facilitating and enhancing Lifelong Learning identifies cities as an important element in this context. The role of a city extends beyond being a space where people learn to one that facilitates learning and ensures the appropriate infrastructure to support learning. Scott [5] highlights that bridging Lifelong Learning and cities is fundamental to Learning Cities.

Numerous transformations are required to achieve the UN SDGs; for example, energy reduction, 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. Most importantly, these transitions must value human rights and the democratic processes in our societies [7]. 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 [8], 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 needs and actions of the citizens, institutions, and communities for sustainable transitions.

The role of the city is central in the literature. There are several perspectives of a city, such as a learning territory [4], an organisation [9], and an urban innovation ecosystem [10, 11], where the cities evolve and innovate themselves to meet the emerging needs of their citizens and institutions. In this context, learning can be interpreted broadly as a change or process leading to a change in behaviour or a transition for the better. 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 community level, and at the institution level, where the city is the institution [12]. We can interpret these ideas to view the city as an entity that includes several elements, such as the citizens and private entrepreneurs, where the city, as well as all the elements within the city, learn. 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 using technology, identified numerous stakeholders 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 city's significant role 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 from within itself and across systems, implying a city that learns from within itself and across cities. 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 with the transitions that take 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, or learning in cities, where cities are considered as learning and innovation ecosystems. Our research questions are: 1) what are the existing frameworks for city transformations that consider aspects of learning in cities while considering cities as innovation ecosystems, and how do they support learning?; 2) what are the key elements and processes for city learning?; and 3) what are the key research gaps in addressing city learning? To answer these research questions, 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 studies that have presented frameworks for city development which have considered the aspects of learning in cities. The identified studies are then analysed to understand the main concepts related to city learning, the key elements within the cities, how they interact with one another, and the different types of processes that are vital to support learning in cities.

Preliminary analyses of the literature review were presented as a conceptual model of a city that learns and innovates [13]. This paper enhances the analysis of the scoping review based on the conceptual model and the results described by Banerjee and Petersen [14] by synthesising the results to obtain a better understanding of the interactions among the elements in a city. This study also enhances the understanding of the processes contributing to city learning. The outcomes of this study can be beneficial not only 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 and identifies the key elements and processes for city learning; Section 5 discusses the aspects of learning in cities. City elements, interrelationships and interactions and the key processes in the context of city learning are described in Section 6. Key research gaps identified in addressing city learning as an innovation ecosystem are provided in Section 7, and reflections on the results of this study are presented in Section 8. Section 9 provides an overall 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 identify the key elements and processes for city learning as an innovation ecosystem. 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 map it systematically.

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" [15]. 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 [16]. 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 followed the stages described in the methodological framework [17]. The stages are 1) identifying the research question, 2) identifying relevant studies, 3) study selection, 4) charting the data, 5) collating, summarising, and reporting the results and 6) synthesising the results. We have adopted this framework by consolidating the stages for conducting a scoping review within 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 recurring characteristics identified and categorise the characteristics according to the different concepts,
- Step III - synthesise the findings to describe the main concepts, present insights based on the results and highlight the gaps related to the objectives of this study.

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

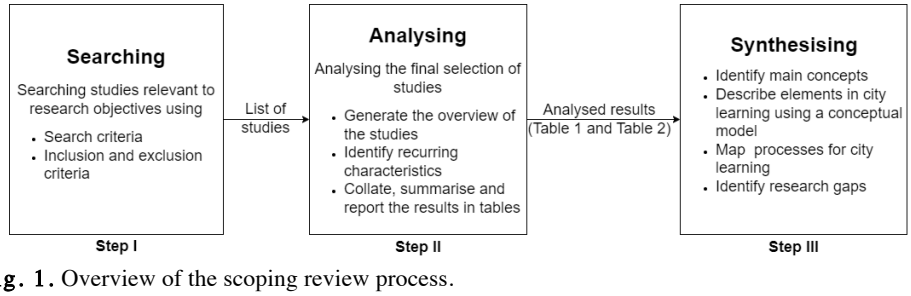

Fig. 1. Overview of the scoping review process.

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. These specific databases were selected

as they are the most relevant ones in the Computer Science research field. The search criteria were determined based on research question 1: what are the existing frameworks for city transformations that consider aspects of learning in cities while considering cities as innovation ecosystems, and how do they support learning? The search strings 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"). The search strings that included learning and cities were to search for papers that reported on city learning. Since we consider cities to be learning and innovation ecosystems, we have included the search strings ("city ecosystem" OR "innovation ecosystem" OR "learning innovation"). The search string "Human Smart Cities" was included to ensure a human-centric element and avoid papers focussing only on Machine Learning solutions in cities. Additional search criteria were not used in this study.

To ensure a comprehensive search, no date restrictions were imposed. We then applied our inclusion and exclusion criteria to select the relevant studies. The exclusion criteria were duplicates, non-English language studies, book reviews, abstract-only studies and presentations.

As our research question focused on existing frameworks for city development that considered elements of city learning, we included only those studies that presented a framework which considers the aspects of learning in cities for developing the cities through contextual innovations. Thus, we set our inclusion criteria such that the studies should have a) considered the development of human-centric cities through innovations and b) presented frameworks for developing human-centric cities considering learning in cities. 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 and learning in cities. In this step, the full text of the studies was then analysed to identify the key characteristics related to city learning. An inductive approach [18] was used for the qualitative analysis to identify the recurring characteristics of city learning and to determine a framework for extracting and presenting the analysis of the studies. The main characteristics are summarised in Table 1. Recurring characteristics from the analysis were identified as the main concepts of city learning. The results from this step are presented as the main concepts in Table 2.

2.3 Step III - Synthesising

In this step, we synthesised 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 have been considered, the processes and

interactions within a city, and the role of ICT in learning in cities. Following an inductive approach [18], we presented a description of the main concepts (Table 2) identified from Step II. We used the city elements identified from the analysis to enhance a high-level conceptual model presented in an earlier study [13] (Figure 3), which identifies the interrelationships and interactions among city elements. This model takes an ecosystem view of cities that can drive innovation and learning in cities.

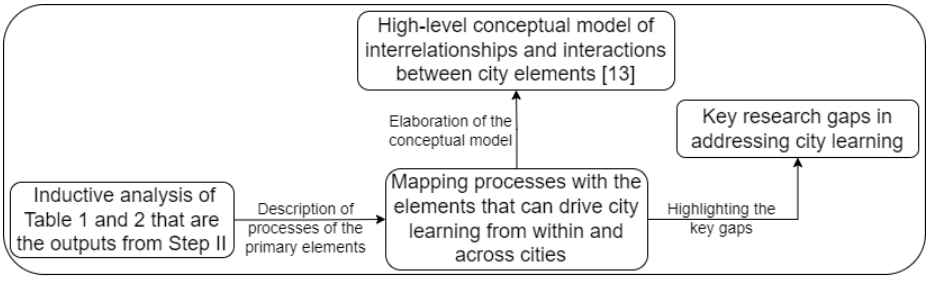

Fig. 2. Synthesis process in Step III

From further analysis of the results from Step II in relation to the conceptual model, we identified and correlated the segments of the conceptual model to the main concepts identified from Step II and described the elements that can drive city learning. We then presented a mapping of the main concepts to the conceptual model for a clear view of the identified city elements. Through further analysis of the results from Step II, we mapped the processes with the elements (Table 4). We highlighted the key research gaps in addressing city learning as an innovation ecosystem from within and across cities. The synthesis of the results from Step II resulted in the answers to the research questions, and these are discussed in Sections 5, 6 and 7. We have presented a schematic representation of this process in Step III in Figure 2.

3 Results from the Literature Review

According to the initial search of 11 databases, 2139 studies were found. After eliminating duplicate entries and non-English studies, 1546 unique studies were identified. Among these, 1370 were excluded after manually reviewing their titles and abstracts. After analysing the full texts of the remaining 176 studies, it was determined that some studies referred to their contributions as frameworks while others referred to them as models. In this study, we considered models as similar to frameworks, and if they met our other inclusion criteria, we included them in our analysis, and we broadly refer to them as frameworks. The assessment of the 176 studies revealed that 162 did not provide a framework for developing cities. Finally, 14 studies were selected based on analysis. We first briefly discussed the overview of each of the selected studies, and then we further analysed them to understand the prevalent concepts and research gaps.

3.1 Overview of the Selected Studies

Smart cities have been viewed as highly innovative ecosystems [19], where extensive social interactions take place to generate economic value by acquiring, processing, and utilising information. The study discusses the term “smart city” and refers to a city trait that comprises an intellectual ability to address several innovative, socio-technical and socio-economic aspects of growth. A smart city reference model is introduced by Zygiaris [19] that represents the city ecosystem and considers the importance of environmental sustainability. The model also illustrates that learning in a city occurs through various layers of interaction and feedback. In the study by de Oliveira et al. [20], the concept of Human Smart Cities (HSC) is seen as leading to the well-being and happiness of citizens 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. According to the study [20], if the concept of smart cities is driven primarily by technology, it eventually falls short of fully utilising the human dimension of cities. To address such shortcomings, the study discusses a platform model to support a neighbourhood, the MyN Platform from the European MyNeighbourhood project, which provides a layered view of the platform and illustrates how Big Data analysis, in conjunction with user participation, could utilise ICT solutions to promote innovation and learning within the city ecosystem. The platform model also considers the natural environment and adaptations from best practices of other cities to create sustainable HSC.

The framework by de Oliveira [21] for developing HSC addresses 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, which is comprised of citizens, academic/research, and private institutions. In this study, HSC is referred to as an urban living lab innovation ecosystem, which applies user-driven open innovation methodologies and tools for the co-design and co-production of social and technological innovation services and processes by citizens and governments together. 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 lead to the development of communities in 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 emphasises that citizen engagement is essential for building a trusted environment for co-creation and knowledge transfer.

Smart cities have been viewed by Caputo et al. [22] as spatial and temporal structures in which social and economic actors interact through institutions and technology to produce, exchange and co-create value. The framework presented in the study described the concept of innovation through learning in smart cities, which views cities as Complex Adaptive Systems (CAS) with numerous interacting and learning agents. The framework suggests that Smart Technologies and Big Data analysis can be used to understand the network of relationships and transactions among elements in a smart city effectively. The study also highlights that citizens need to be motivated to participate in the development of services, and 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 evolution of elements and their interrelationships in the society of a city. The study also suggests that decision-makers can utilise the framework to learn to create citizen-centric innovations.

The study by Spinosa and Costa [23] proposes a framework for describing innovation for a humane and sustainable smart city based on observations of Curitiba in Brazil. The framework consists of three components: the main conceptual drivers, a 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 cities, and sustainable development. It argues that the Quadruple Helix model [24] involving four types of stakeholders is advantageous compared to the Triple Helix model [25, 26] because 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 interaction processes are essential in a city and finds that mobility and transport issues deeply influence urban planning processes. The study concludes 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.

The research work by Preece [27] presents a framework for building Learning Cities which are based on the Lifelong Learning paradigm, which aligns with the first Learning Cities conference report of UNESCO UIL in Beijing [28]. The study also notes that most literature on Learning Cities is practitioner- or policy-based and typically celebratory in nature. The conceptual framework for innovation and learning in smart cities proposed by McKenna [29] is also 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. In this view of lifelong learning, human and other resources are mobilised to promote inclusive learning from basic to higher education, revitalising learning in families and communities and facilitating learning for and in the workplace. This is achieved through extending the use of modern learning technologies, enhancing the quality of learning and nurturing a culture of lifelong learning. The proposed framework suggests that the technology-people-institution framework can be used to expand and rethink learning in smart cities. The study suggests that learning flows and relationships should be rethought to enable interactions and mutual learning between local government, educators, and learners.

The conceptual framework for learning and creativity, driven by more aware people interacting among themselves and aware technologies, presented by McKenna [30] presents an integral view of people, technologies, and cities. The study highlights that aware technologies can assist citizen/visitor education and awareness in smart cities. It also emphasises that partnerships between people and technologies and learning can impact the comfort of individuals residing in the city and that innovations considering people's needs and comfort levels can improve their quality of life. McKenna [31] presented an expanded version of the conceptual framework that she had introduced in [30], emphasising the significance of learning and knowledge infrastructures for promoting learning in smart cities. It promotes a Learning City aligned with a fundamental component of smart cities, where the focus is on the human dimension and fostering creativity, with a significant focus on the essential roles of individuals, education, learning, and knowledge. 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 city elements such as community participants as partners and learning from other cities (e.g., through networks of cities) [31].

Schuurman et al. [32] have presented a framework representing the high-level conceptual anatomy of Living Labs based on a detailed case study analysis of LeYLab, a Living Lab for an experimental fibre-to-the-home (FTTH) network in Kortrijk, Belgium. The study discusses that Living Labs are open innovation ecosystems, by virtue of direct links between the citizens (potential users), local

private companies (potential utilisers) and local organisations (potential providers), that enable sustainable innovations in real-life environments through learning based on the iterative processes of participant feedback. 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. The study highlights that cities are well-suited for acting as Living Labs due to their direct connection to citizens, local private companies, and organisations. Concilio et al. [10] presented a high-level model for developing HSC, which included technological and social innovations through Living Labs, infrastructure and platform investments, network building, citizen empowerment and stakeholder engagement. The study presented an HSC grounded on complementary "softer" features of "smartness", such as clarity of vision, citizen empowerment, and participation in sustainably transforming cities through learning. It also proposed rethinking the Learning City to feature interactions between government, learners, and educators in collaborative idea generation.

The framework proposed by Layte and Ravet [33] 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. According to the study, it is important to comprehend the interconnectedness of individual, community, organisational and territorial learning 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. It discusses the usage of ICT for the utilisation of knowledge, information and learning technologies (KILT) for documentation, assessment, and support technology-aided transformations of education, training, and human resource development. The study, subscribing to the paradigms of Lifelong Learning and Lifewide Learning, further discusses that due to the requirements of a knowledge economy and a learning society, education, training, and learning must be re-evaluated to support lifelong and widespread learning. The term "knowledge economy" has been described as how 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. The concept of "learning society" has been referred to in the study as 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 emphasises the growth of social capital.

As per the study outlined by Mayangsari and Novani [34], a city can be viewed as a complex organisational system comprising various elements and components 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 can affect or be affected by the organisation's objectives. The study also presented a framework for a co-creation scheme in Bandung smart city involving multiple stakeholders, emphasising the importance of city representatives acting as enablers. Using an ICT platform, this framework promotes learning through the exchange of experiences and feedback, connecting citizens, private institutions, and knowledge providers, as well as professionals who provide services in the city and academic and research communities.

A conceptual framework describing multi-level social innovation was presented by Costales [35], which considered the interdependencies of Sources Of Innovation (SOI) that refer to the perceptions of deficiencies that initiate the learning curve of innovation and Loci Change (LOC), referring to the structures that enable the learning curve to disseminate through the system. The study presented a high-level view of the city society, which is stratified into three levels: the individual (micro), organisational

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

Study	What has been considered a city	How learning is addressed	Interactions between key elements that have been considered	ICT to support learning
[33]	Learning territories while viewing from an organisational perspective	• Learning communities at the heart of the idea of a learning territory (city). • City learns like an organisation by linking individual, community, organisational and territorial learning through the process of organisational learning	Interactions between: * Citizens * Learning and professional communities * Education providers * Businesses	Learning Management Systems for utilisation of knowledge, information and learning technologies (KILT)
[19]	Smart cities as IT-based innovative urban ecosystems	A layered conceptual reference model of a city for technology-enabled innovation through learning	Social interactions and Feedback	ICT for connections between entities
[34]	A complex system of multiple systems with various elements and stakeholders that have competing interests and considers the city as an innovation ecosystem	Modelled for the stakeholders to: • learn the city's characteristics, • reflect on the vision decided by the city representatives, • provide the appropriate scientific reasons for deploying the projects	Interactions and feedback between stakeholders (enablers, utilisers, providers, and users)	ICT Platforms supporting interactions between stakeholders for value creation through knowledge-sharing and collaboration
[20]	HSC for improving the quality of life of the citizens	Models the HSC concept as an improvement of the smart city, focusing on creating a healthier and happier environment for citizens.	Learning from experiences from * Individuals * Communities * Public and private bodies * Other cities	Service platform for * Interconnection between individuals and between cities * Knowledge sharing
[21]	HSC and an urban living lab innovation ecosystem	Citizen engagement is key to learning and knowledge	Interactions between individuals (citizens) and other	Service platform for community collaborations and

Interaction Design and Architecture(s) Journal - IxD&A, N.60, 2024, pp. 32 - 58
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		transfer	stakeholders	facilitations
[29]	Smart cities as Learning Cities through lifelong learning for citizens [28]	Maps people, technology, and information through the perspective of Learning Cities for driving innovation in smart cities	Interactions between * People * Technology * Information	Social radio tool for creating contextual awareness for driving innovation through learning and collaboration
[32]	City neighbourhoods (that comprise cities) as Living Labs which are open innovation ecosystems	Models the anatomy of Living Labs in cities for driving innovation through learning	Interactions between * Utilisers * Users * Provider * Researchers	* Smart devices given tothe users * Mobile or fixed networks rolled out in a given environment * Sensor network
[27]	Learning City [28]	Explains how Learning Cities are built through the framework presented by UNESCO [28]	Dialogue between people and organisations through complex interactions	To support the sharing of data
[10]	HSC based on the ideas of Living Labs.	Learning through utilising existing smart city visions and city strategies utilising data, technology and community Living Labs	Interactions between * People * Government * Technology	* Smart grids and Sensors * Service Apps and Platforms * Open Data
[22]	An ecosystem view, as a CAS, with users, services and Technologies	A CAS view, where cities adapt by utilising the support of smart technologies to respond to citizens' behaviours and expectations	Interactions between * Social actors * Economic actors	* Smart devices * Big Data
[23]	HSSC that merges concepts from urban development focused on citizens, smart cities, and sustainable development principles	• A descriptive framework for transforming the city into an HSSC. • Includes concepts and models for adapting, learning and city development approaches • Stakeholder participation	Close interaction between * Local community * Government bodies * Private institutions * Academia involved in the innovation process	* Communication platform between the public administrator and citizen QR codes and smart devices to share information
[30]	Learning Cities as smart urban environments/regions.with the smart city dynamic including people-technologies-cities.	A conceptual framework for learning and creativity, incorporating the notion of	Interactions between * Technological systems and people that influence learning	Awareness technologies, such as social media and digital platforms that can

		comfort	* City infrastructures and people * And across people and Institutions	assist in citizen/visitor education and awareness
[31]	Learning City, where the focus is on the human dimension and fostering creativity. Focus on the roles of individuals, education, learning, and knowledge.	• A model based on the interactive dynamics of people— technologies—cities. • Learning through community participation and knowledge and data infrastructures.	Interactions between * People and knowledge and data infrastructures * People and learning infrastructure	* Smart devices such as sensors and IoT devices Social media
[35]	An ecosystem from an organisational perspective	A multi-level model of social innovation through learning within the urban context	Interactions between the micro, meso and macro levels of a city (or organisation)	Technological tools to ensure efficient collaboration among the city's organisational actors within and across the strata

(meso), and system (macro), which possess different administrative and participatory powers. The study highlighted that SOI and LOC occur at different levels, such as individuals, groups of individuals, and institutions. This framework discusses learning at the city level from different perspectives while considering 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 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 considered, 2) how learning in a city has been addressed, 3) the interactions between key elements in a city, and 4) the role played by ICT to support learning. The analysis of the studies resulted in the identification of key characteristics that 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, and digital technologies, such as 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.

Based on the analysis of the recurring characteristics from the information provided in Table 1, we identified the main concepts about cities and the processes and interactions related to learning in cities. We categorised the main concepts for a better understanding of learning in cities as follows: 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. This synthesis identified how the main concepts were addressed in the different studies, and this is presented in Table 2.

Table 2. Extraction of the main concepts from the analysis of the recurring characteristics

Main concepts	Characteristics	Reference to literature
Broad perspective through which a city is viewed	Learning territory	[27, 29, 31–33]
	Organisation	[33, 35]
	CAS	[22, 34]
	Urban innovation ecosystem	[19, 21, 22, 30, 35]
	Living Lab	[10, 21, 32]
	Smart city	[10, 20, 22, 23, 31]
Elements of a city	Individuals	[10, 19–23, 27, 29–35]
	Group of individuals and institutions	[10, 19–23, 27, 29, 30, 32, 34, 35]
	Government institutions	[10, 19–21, 23, 27, 29, 30, 32, 34, 35]
	Academic and research institutions	[19–21, 23, 27, 29, 32, 34, 35]
	Private organisations and	[19–23, 27, 32–35]

	industries	
	Other Cities	[20, 33]
	Technology	[10, 19, 29–31]
	Natural environment	[23]
Processes crucial for city innovations through learning	Planning innovations with leadership	[10, 27, 33]
	Motivation and participation of Citizens	[10, 20–23, 27, 29–33, 35]
	Engagement and empowerment of Citizens	[10, 20–23, 27, 29–32, 35]
	Collection and sharing of information	[19, 21, 23, 27, 29–35]
	Sharing ideas	[10, 20, 21, 23, 27, 29–32, 35]
	Codesigning	[10, 20, 21, 23, 27, 29–32, 35]
	Providing feedback	[19–23, 27, 29–35]
	Reflecting on experiences and available contextual information	[10, 19–21, 23, 27, 29–35]
Interactions between the elements of a city	Formal interactions through education	[23, 27, 29–31, 33–35]
	Interactions in social settings	[10, 19–21, 23, 27, 29–35]
ICT support for learning in cities	Formal education and training for human resource development	[23, 27, 29–31, 33–35]
	Social connectivity	[10, 20–22, 29, 31–33, 35]
	Communication between different elements of a city	[10, 19–23, 27, 29–35]
	Sensing, collection and sharing of information	[10, 20–23, 27, 29, 31–35]

In the following sections, we present the synthesis of the analysis of the studies and discuss these with respect to the research questions.

5 Aspects of Learning in Cities

We analysed the main concepts in city learning to answer our research question 1, which is to identify the existing frameworks for city transformations that consider aspects of learning in cities while considering cities as innovation ecosystems and to understand how they support learning. We have found that the selected studies have considered cities from different perspectives of learning territories, organisations, CAS, urban innovation ecosystems and smart cities. However, these are not mutually exclusive perspectives. The urban innovation ecosystem, CAS and organisational perspectives take a systems 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 that provide citizens with access to essential services such as 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 a 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 (based on the concept of a Learning 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. We found from the results that in Learning Cities, the interactions for the information transfers between individual citizens have been considered to take place broadly in formal education and informal social interaction settings [27, 28, 30, 31].

For sustainable twin transformations, viewing cities holistically as ecosystems as per the systems thinking approach has been advocated for understanding the evolutions of elements and interrelationships 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. 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 among its stakeholders.

As discussed, a city can be viewed through the systems approach as a large-scale complex, self-adaptive organisation wherein 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 that can take place in the different levels of a city and the mechanism of learning described in some organisational learning frameworks, such as the 4I [36] and ICULT [37] frameworks, where the learning at the organisational level emerges through the learnings from interactions and feedback at the individual, group and organisational levels. From Table 2, we find that ICT can be utilised to support formal education, training for human resource development, social connectivity, communication between different elements of a city, sensing through smart sensors and overall collection and sharing of contextual information. 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.

6 City Elements, Interrelationships and Interactions and Key Processes

We have identified the need to address city learning from an ecosystem perspective. This necessitates an understanding of how the learning can take place and who can learn from whom or what, e.g., a process. An understanding of the key elements of the city ecosystem, how they are related to each other, and the processes for interactions among them is crucial to describe the learning process of a city from an ecosystem perspective. This understanding will provide an answer to research question 2: what are the key elements and processes for city learning? From Table 2, we can find that the key elements of a city ecosystem for learning in cities are the individuals, groups of individuals and institutions, government institutions, academic

and research institutions, private organisations and industries and other cities, technology, and the natural environment.

These key elements can be divided into the following two broad categories: 1) the external elements identified as other cities from which a city can learn, i.e., due to which learning across cities can take place, and 2) the rest as internal elements of a city ecosystem wherefrom through the interactions among the internal elements, city learning can take place from within itself. We further elaborate on the key elements that have been identified in the following subsubsections, highlighting the interrelationships and interactions between them. The external elements, which are other cities comprising their own ecosystem of elements and interactions, are also described.

6.1 Human-Driven Environment

Citizens are the central entities in cities, highlighted in all the frameworks in the selected studies. We find that humans are the common element in a city ecosystem, consisting of individuals, groups of individuals and institutions, government institutions, academic and research institutions, private organisations, and industries. This is because humans, or citizens, are the basic constituent elements associated with different levels of power, such as civic bodies, NGOs, and public/private organisations. Such organisations can be perceived to be represented by groups of individuals who are citizens of a city with different levels of authoritative powers based on the hierarchies within the organisations or the society. These elements are all part of the human-driven environment that functions at different levels of authoritative and implementative powers and provide/produce different services/products. The human-driven environment is the proactive component in a city ecosystem and is responsible for initiating, designing, and implementing any innovation for the development of a city. The elements comprising the human-driven environment can be deemed as the primary elements of a city ecosystem and thereby form the set of active stakeholders of a city.

6.2 Technological Systems

The synthesis of the results shows that technology-aided service systems can influence learning in cities and innovations for developing cities. Technological systems have been considered a constituent element of the city ecosystem rather than a mere facilitator due to the ubiquitousness of technology in a city. We find that technological systems can not only act as a medium and support the human-driven environment in their mutual communication and knowledge transfer, but they can also drive the collection and analysis of information regarding various service systems. They can present analyses of information about the natural environment retrieved through different sensing mechanisms. However, the technological components of a city ecosystem are designed, developed, operated and utilised by the human-driven environment that corresponds to the primary elements. Thereby, the technological components of a city ecosystem can act as secondary elements that can impact the city ecosystem.

We have found that the use of ICT solutions has been the predominant part of the technology component in the selected studies. ICT solutions, such as digital technology tools that support modern computing, can enable people and organisations to interact digitally. The use of ICT solutions has been discussed in the selected

studies as a tool to enable more interactive and intuitive teaching and 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 content, data sharing, documentation, and assessment of the outcomes of the teaching and learning processes. These tools, such as digital learning platforms and smart devices, have been focused on ensuring better learning outcomes for learners. ICT solutions have also been discussed for communication between the learning entities in a city to enable Lifelong Learning for transforming cities into Learning Cities. Communication between the learning entities has been achieved through the use of social media, smart device networks, data-sharing platforms, and mobile or fixed communication networks. Upon synthesising the results, we find that ICT-enabled service platforms are also discussed as crucial tools for supporting collaboration among the stakeholders of a service system by enabling interconnections between them and sharing 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.

6.3 Natural Environment

From the review results, we also find that environmental parameters can greatly impact the life experience in cities and influence their transformations. We find that considering a city as a knowledge economy, the natural environment has also been considered a crucial entity alongside that of public authorities, industry, academia, and citizens) for innovations in a city. Consequently, this approach reflects the perspective of the Quintuple Helix framework for innovation [38]. The natural environment is a key element in the city ecosystem that can facilitate, restrict, or determine the city's transformations. Both the human-driven environment and technological systems can influence the natural environment, leading to its evolution, which in turn can impact them. Learnings from such interrelationships are crucial in determining the sustainable citizen-centric innovation of cities. However, even though the status of the natural environment influences the path of innovation, it is a type of reactive element which impacts the other elements of a city ecosystem through its evolution due to the interactions with the human and technological components of the city ecosystem.

6.4 Other Cities

Elements of a city can be inspired and influenced by innovations, experiences, and contextual knowledge of external city ecosystems. These city elements can accordingly propel transformations of its own city ecosystem to address contextually relevant emerging challenges and opportunities. The elements within a city, which have positive or negative interdependencies among them, interact with each other and across cities to form a complex ecosystem. This relates to the fact that a city can learn from both within itself as well as from the experiences of other cities. Thereby, other cities can be considered an important part of any city’s ecosystem. Learning across cities, or city-to-city learning, refers to when a city learns from other cities [20, 33]. Such learning has been highlighted to bear the essence of learning akin to organisational learning [33, 35], wherein an organisation can learn from other organisations.

6.5 City Elements as a Conceptual Model of a City Ecosystem

From the results of this literature review, we find that apart from the human-driven components, technological systems, the natural environment, and other cities, key elements of a city that can shape the evolution of a city. An earlier study [13] based on a preliminary analysis of this literature review has considered the ecosystem view of a city and presented a high-level view of the interrelationships and interactions between the city elements that can drive city learning from within and across cities. The high-level view is illustrated as a conceptual model in Figure 3.

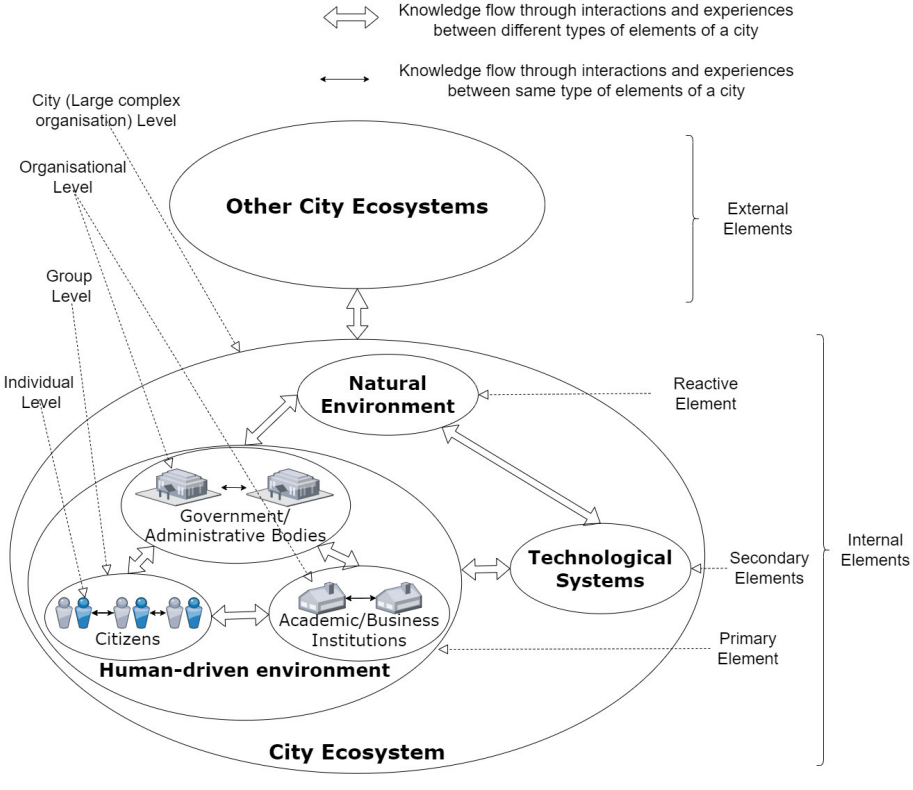

Fig. 1. High-level conceptual model of a city ecosystem presenting the interrelationships and interactions between city elements that can drive city learning from within and across cities, adapted from [13]

The illustration of city elements is represented by two large, connected ellipses, one for the internal elements of a city ecosystem and one for external elements comprising other related city ecosystems. The ellipse for the internal elements of a city ecosystem comprises three interconnected smaller ellipses representing the human-driven environment, technological systems, and the natural environment. Based on the discussions in this paper, we have marked the human-driven environment, natural environment, and technological systems as primary, reactive, and secondary elements, respectively.

As discussed earlier, the primary elements comprising the human-driven environment are the proactive elements responsible for initiating, designing, and

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implementing any innovation for developing a city and can drive city initiatives. The human-driven environment of the city ecosystem can drive the evolution of the overall city ecosystem through innovation based on its evolution through learning from its interactions. We further analyse the key elements of a city, as shown in Table 2 and the high-level view of a city ecosystem, as shown in Figure 3. We then map the primary elements of a city based on the conceptual model to their constituent elements that have been identified in Table 2. We present this mapping in Table 3.

Table 3. Constituent elements within the high-level conceptual model of a city ecosystem [13]

Broad classification of city elements as illustrated in the high-level view in Figure 3		**Corresponding constituent elements**
Human-driven Environment	Citizens	Individuals, NGOs, Civic groups
	Academic/Business Institutions	• Academic and research institutions • Private organisations • Industries
	Government/ Administrative Bodies	Government institutions
Natural Environment		Ambient natural environment comprising of: • Land • Air • Water • Plants • Animals
Technological Systems		ICT components comprised of: • Digital platforms • Smart grids • Smart devices, such as sensors and IoT devices • Service Apps and Platforms • Open Data
Other City Ecosystems		Other cities

6.6 Mapping the Processes Related to City Learning

In this sub-section, we focus on the processes between the elements of a city ecosystem identified through the literature review to classify the city elements (from Table 3) and map the processes among all the elements and the primary elements of a city ecosystem that can drive city learning. Referring to the conceptual model of a city shown in Figure 3, we highlighted that the human-driven environment represents the primary elements in a city ecosystem comprised of both individual entities and groups of citizens, academic and business institutions and government and public bodies. Based on this, we find that the primary elements can utilise technological systems as a medium and to support the carrying out of the processes involved with other elements. Through reflections on interactions with the natural environment and information about the natural environment acquired through several means, such as smart sensors, the primary elements can acquire contextual knowledge for driving

ideas and plans for sustainable innovations. The primary elements can also reflect upon the characteristics and available information of other city ecosystems for generating their ideas and plans for contextual innovations. These processes can ensure learning of contextually relevant knowledge about challenges, opportunities and requirements of service systems related to diverse aspects of a city ecosystem, such as business, recreation, comfort, transport, environment, goods availability, medical care, and education. Acquisition of such knowledge can drive sustainable human-centric innovations in a city ecosystem.

Citizens can share ideas and contextual feedback based on their reflection on experiences and analysis of available contextual information with fellow citizens, or groups of citizens, academic and business institutions and government and public bodies. Such sharing of ideas can lead to building partnerships between the different elements and generating a richer knowledge base that could contribute to the learning of contextually relevant knowledge by the primary elements. Citizens can also engage in co-design activities along with other primary elements for developing required innovations, which also involve iterative cycles of learning.

The collection of relevant information from all relevant primary elements for generating a knowledge base for contextual innovations needs to be done by the academic and business institutions and government and public bodies of a city. They are also responsible for collecting and analysing relevant information from other city ecosystems by utilising technological platforms for contextual innovations in their city. They also need to collect information about the natural environment of a city through technological systems such as smart sensors. In addition to these processes, they can also share ideas among themselves along with the responsibilities for planning innovations for city development and co-designing innovations. These processes can contribute to the learning of contextually relevant knowledge by academic and business institutions as well as government and public bodies. These processes highlight the importance of the partnerships between and across the academic and business institutions and government and public bodies of a city. Based on the synthesis of the results from the literature review (Tables 1 & 2) and the classification of city elements shown in Table 3, we have presented a mapping of the processes between all the elements and the primary elements of a city ecosystem that can drive city learning from within and across cities in Table 4.

7 Key Research Gaps in Addressing City Learning as an Innovation Ecosystem

Based on the synthesis of the analysed results, we present the key research gaps in addressing city learning as an innovation ecosystem to answer our research question 3: what are the key research gaps in addressing city learning? Our study shows that even though the selected studies have presented frameworks for transforming cities through innovations while accounting for learning in cities, they have not addressed the concept of how a city as a system can learn.

Citizens have been the centre of Lifelong Learning and Lifewide learning paradigms that have been identified to be prevalent among the frameworks. Nevertheless, questions such as how that learning can be utilised at a given time for addressing any specific emerging challenge or opportunity, how to ensure continuous contextual innovation of cities and how a city as a system can learn need to be addressed. Approaches such as Living Labs have highlighted the utilisation of co-

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Table 4. Mapping of the processes between all the elements and the primary elements of a city ecosystem [13]

		Elements of a City Ecosystem					
		Citizens	**Academic/Business Institutions**	**Government/ Administrative Bodies**	**Technological Systems**	**Natural Environment**	**Other City Ecosystems**
Primary Elements of a City Ecosystem	**Citizens**	• Sharing of ideas • Codesigning innovations	• Sharing of ideas • Codesigning innovations • Providing feedback	• Sharing of ideas • Codesigning innovations • Providing feedback	Utilising as a medium and support to carry out the processes involved with other elements	Reflecting on experiences and available contextual information	Reflecting on experiences and available contextual information
	Academic/ Business Institutions	• Codesigning innovations • Collection and sharing of information	• Sharing of ideas • Planning innovations for city development • Codesigning innovations • Collection and sharing of information	• Sharing of ideas • Planning innovations for city development • Codesigning innovations • Collection and sharing of information	Utilising as a medium and support to carry out the processes involved with other elements	• Collection of information • Reflecting on experiences and available contextual information	• Collection of information • Reflecting on experiences and available contextual information
	Government/ Administrative Bodies	• Codesigning innovations • Collection and sharing of information	• Sharing of ideas • Planning innovations for city development • Codesigning innovations • Collection and sharing of information	• Sharing of ideas • Planning innovations for city development • Codesigning innovations • Collection and sharing of information	Utilising as a medium and support to carry out the processes involved with other elements	• Collection of information • Reflecting on experiences and available contextual information	• Collection of information • Reflecting on experiences and available contextual information

design and co-development activities to address emerging challenges and opportunities in a city through collaboration among its stakeholders.

Similarities have been highlighted between the learning that can take place at the different levels of a city and organisational learning, wherein organisational level learning is described to be emerging through the learnings from interactions and feedback at the individual, group, and organisational levels. However, such organisational learning models are yet to be explored in the context of frameworks for city transformations.

We observed from the synthesis of the results that citizen participation and engagement are crucial for empowering citizens and driving transformations in cities through learning from citizens' interactions, ideas, knowledge from their experiences and reflective analyses and feedback. This necessitates that the citizens be motivated to participate in participatory and engagement activities. Here, we refer to the processes for citizen participation and citizen engagement as two distinct processes. This is because citizen engagement requires an active, intentional dialogue between citizens and public decision-makers, whereas only citizens themselves can participate on their own [39]. In this context, we also comprehended that taking valid contextual inputs from citizens to drive city learning for sustainable innovations is a major challenge. We also found that citizens' privacy and trust concerns need to be accounted for to ensure citizen engagement. However, based on the synthesis of the results, we found that there has been a lack of focus on systematically motivating citizens to ensure their participation and engagement.

The results show that ICT solutions have been discussed for driving contextual city transformations through co-design and co-development activities apart from supporting formal education and human resource development training. However, there is a lack of emphasis on how ICT solutions can assist relevant stakeholders in reflecting on their experiences and available contextual information. The frameworks presented in the selected studies in this review also do not provide a mechanism through which ICT solutions can instil trust among all relevant stakeholders, accounting for citizens' privacy concerns and ensuring citizen empowerment through their participation and engagement. An ICT-aided generic framework that can support the dialogic processes between a city's stakeholders while extracting valid contextual inputs from the citizens and relevant stakeholders and analysing them for contextual sustainable innovations in a city ecosystem through learning from within itself and across cities is missing. Furthermore, we find that the literature did not address how learning in a city as a system can be supported by ICT.

We found that emphasis on two aspects of transforming cities is lacking in these frameworks. One of the aspects is for the implementation of the innovations, and the second one is for evaluating the outcomes after implementation of the innovations to assess the extent of success (or failure) that has been achieved with respect to expectations of their initial planning phase. This evaluation exercise shall promote a sense of transparency among all the stakeholders, i.e., the active elements responsible for the city development through the innovations. It is imperative that innovations be implemented to transform cities, and after that, the outcomes of the innovations need to be evaluated so that the relevant stakeholders can reflect on the evaluation information to drive the next iteration of innovations. Such an iterative process is necessary to ensure that the city as a system can evolve through continuous learning from its internal elements and external elements. A generic framework that can continuously enable a city to learn as a system is missing.

The frameworks presented in the selected studies are conceptual frameworks, and they do not present a working model that can help monitor and assess the evolution of a city. A generic framework that can continuously enable a city to learn as a system is missing. A framework that has a systems view of a city and can evaluate the

outcomes of innovations of its service systems to present a holistic view of how innovations to one service system may be affecting other interrelated systems in a city is missing. Such a framework can help relevant stakeholders holistically and transparently reflect on the outcomes for driving further innovations and thereby can support a city learn as an innovation ecosystem from within and across cities.

8 Reflecting on the Results

Based on the analysis of the results, we have elaborated on the description of the elements and mapped them with the processes that can drive city learning from within and across cities. The ultimate goal is to drive sustainable citizen-centric innovations tailored to city-specific contexts. Considering the importance of the citizens of a city, the transformations of a city need to be done by having citizens onboard for the transformative processes. We find that the participation and engagement of citizens is a crucial part of any transition in cities; e.g., for decarbonisation or to achieve a digital transformation, citizens need to be engaged to change their behaviour in line with the desired transformation. Thus, for an effective transition, the citizens need to be empowered and motivated to ensure their participation and engagement to drive learning in cities for contextual innovation and development. Such empowerment and motivation can enable co-design and co-development through the sharing of ideas, collection of information, reflective analysis of available information and feedback. Furthermore, empowerment and motivation are often facilitated in the city through processes aimed at transitioning the city to align with the desired transformations. This is aligned with the idea of twin transitions ensuring sustainable transformations of cities. Even though there are various means and modes for enabling participation and engagement activities for codesigning, motivating citizens to participate and engage in the development of cities through sustainable innovations is challenging. Moreover, we comprehend that taking valid contextual inputs from the citizens and relevant stakeholders and processing them so that the inputs can constructively contribute to transforming cities through innovations is also a major challenge that needs to be addressed. The citizens form a crucial element in driving any transformation in cities; hence, city learning is an important aspect of twin transitions.

This study shows that leadership has been considered crucial for any developmental activity in a city. Innovation can be initiated, managed, and implemented by the city administrator as well as by individuals, groups of individuals, government institutions, academic and research institutions, private organisations, and industries, with the support of the city administrator, who can take the leadership role. Considering the city as an ecosystem, initiatives taken by any one of the city elements would likely have an effect on the other city elements.

Technological systems can serve both as the medium and support for processes to carry out the management, engagement, participatory and generation of knowledge base for supporting city learning for contextual innovations in a city. The natural environment in this context is a reactive element, and its status can drive the necessity and direction of innovations. Other city ecosystems can also act as a reference point, which can be observed by the city elements and influence the innovation processes in a city ecosystem.

9 Conclusion

Cities are central to achieving sustainable digital transitions supporting education and Lifelong Learning. This study focuses on the role of a city in learning as an ecosystem and its relevance for achieving the UN SDGs. The objective of this study has been to understand city learning, or learning in cities, where cities are considered as learning and innovation ecosystems. To meet this objective, the study has provided answers to the research questions: 1) what are the existing frameworks for city transformations that consider aspects of learning in cities while considering cities as innovation ecosystems and how do they support learning?; 2) what are the key elements and processes for city learning?; and 3) what are the key research gaps in addressing city learning? The study focused on what and how a city can learn as an innovation ecosystem to drive human-centric city transformations by exploring existing frameworks for city transformations. To accomplish this, we conducted a scoping review to identify studies which have presented a framework that considers the aspect of learning in cities for developing the cities through contextual innovations. We analysed the results to identify the key elements and processes that can drive city learning from within and across cities. We mapped the elements and corresponding processes that can drive city learning. This mapping can be used as a framework to design solutions such as ICT solutions to support city learning. This study contributes to the understanding of a city as a system and the main concepts encompassing the elements and processes for city learning as an innovation ecosystem.

The results of this study illustrate how a city, as a system, resembles a large-scale complex organisation that can learn through individual, group, and system levels from within itself and across cities. The results also highlight that mere access to ICT-enabled communication and information transfer between stakeholders is insufficient to enable a city to learn as a system. Ensuring citizen participation and engagement is essential for empowering citizens and driving human-centric transformations through learning from their interactions, ideas, knowledge, experiences, 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 its citizens' emerging needs and aligns with and supports the numerous transitions taking place in cities. There is a need to develop a generic framework that utilises the potential of ICT solutions to support city learning. This study contributes to understanding how a city as a large-scale complex organisation system can learn.

In our study, we identified a lack of focus on three critical areas in the existing frameworks for city transformations and learning in cities. The first is the implementation of innovations; the second is the evaluation of these innovations post-implementation to measure their success against initial expectations; and the third is a framework which can holistically assess the ripple effects of innovations of different service systems in a city. The process of outcome evaluation can foster transparency among all stakeholders involved in city development. Holistic evaluation of the outcomes after the implementation of the innovations is important as this allows stakeholders to use the evaluation information to guide future innovations. This iterative cycle is vital for a city's sustainable evolution, wherein it continuously learns from its internal and external elements.

This study also identified the key research gaps in the literature in addressing city learning as an innovation ecosystem. While there are frameworks that support transformation in cities, there are no frameworks that address how a city as a system could learn. While one of the main processes for supporting learning in cities is to motivate and engage people, there is a lack of focus on systematically motivating citizens to participate and engage in city activities. The study also highlighted how

ICT has been utilised in city processes. However, the literature did not address how learning in a city as a system can be supported by ICT.

The main challenge in conducting the scoping review presented in this paper was identifying the relevant search databases and defining relevant search, inclusion, and exclusion criteria. This is mainly due to the multi-disciplinarity of the subject. Moreover, the review is inspired by the view of 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. The rigour of our analyses could also be enhanced. Hence, the main limitations of this study are related to these challenges.

One direction of our future work would be to enhance the search criteria and conduct a systematic literature review. The mappings between the elements and the processes that can drive city learning and the key research gaps identified in addressing city learning as an innovation ecosystem can provide a framework to ascertain whether or to what extent a city is learning as an innovation ecosystem. As part of our future work, we will also conduct case studies of European Smart City Projects to validate our findings. Our future research will also focus on designing ICT support for city learning, especially to alleviate challenges in motivating citizen participation and engagement and taking valid contextual inputs from relevant stakeholders. The results from this study can also be used by researchers, policymakers, and public/private service providers in the context of city learning that can drive collaborative, holistic city transformations through sustainable citizen-centric innovations.

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References

1. Gianni F.V., Divitini M.: Technology-enhanced smart city learning: A systematic mapping of the literature, IxD&A Interaction Design & Architecture (s), 27, pp. 28–43, (2015), DOI: https://doi.org/10.55612/s-5002-027-002
2. UNESCO: Lifelong learning, learning cities and smart cities | UIL, https://uil.unesco.org/event/webinar-lifelong-learning-learning-cities-and-smart-cities
3. Thematic Action Track 4 on Digital learning and transformation discussion paper,https://transformingeducationsummit.sdg4education2030.org/AT4DiscussionPaper
4. Komninos N.: Intelligent cities: innovation, knowledge systems and digital spaces, Routledge, (2013), DOI: https://doi.org/10.4324/9780203857748
5. Scott L.: Learning Cities as Smart Cities: Connecting Lifelong Learning and Technology Examining the Socio-Technical Impact of Smart Cities, pp. 68–90, IGI Global (2021), DOI: https://doi.org/10.4018/978-1-7998-5326-8.ch003
6. Muench S., Stoermer E., Jensen K., Asikainen T., Salvi M., Scapolo F.: Towards a green & digital future JRC Publications Repository (2022), DOI: https://doi.org/10.2760/977331
7. Soe R.-M.: Smart Cities and Smart Regions Roadmap in Dascalu, M., Mealha, Ó., and Virkus, S. (eds.) Smart Learning Ecosystems as Engines of the Green and Digital Transition, pp. 75–100, Springer Nature, Singapore (2023), DOI: https://doi.org/10.1007/978-981-99-5540-4_5
8. Cuperstein I.: Cities, at the forefront of sustainable transformation, Field Actions Science Reports. The journal of field actions, pp. 48–53, (2022)

9. Papageorgiou G., Demetriou G.: Investigating learning and diffusion strategies for sustainable mobility, Smart and Sustainable Built Environment, 9, pp. 1–16, (2020), DOI: https://doi.org/10.1108/SASBE-02-2019-0020
10. Concilio G., Marsh J., Molinari F., Rizzo F.: Human Smart Cities: A New Vision for Redesigning Urban Community and Citizen's Life Knowledge, Information and Creativity Support Systems: Recent Trends, Advances and Solutions, pp. 269–278, Springer International Publishing, Cham (2016), DOI: https://doi.org/10.1007/978-3-319-19090-7_21
11. Granstrand O., Holgersson M.: Innovation ecosystems: A conceptual review and a new definition, Technovation, 90, pp. 102098, (2020), DOI: https://doi.org/10.1016/j.technovation.2019.102098
12. Petersen S.A., Concilio G., Oliveira M.: Smart Neighbourhood Learning – the case of MyNeighbourhood, IxD&A, pp. 66–78, (2015), DOI: https://doi.org/10.55612/s-5002-027-004
13. Banerjee P., Petersen S.A.: Learning in cities from within and across cities: A Scoping Review, Triple Helix, (2023), DOI: https://doi.org/10.1163/21971927-bja10044
14. Banerjee P., Petersen S.A.: How Cities Can Learn: Key Concepts, Role of ICT and Research Gaps in Dascalu, M., Mealha, Ó., and Virkus, S. (eds.) Smart Learning Ecosystems as Engines of the Green and Digital Transition, pp. 53–73, Springer Nature, Singapore (2023), DOI: https://doi.org/10.1007/978-981-99-5540-4_4
15. Peters M.D.J., Godfrey C.M., Khalil H., McInerney P., Parker D., Soares C.B.: Guidance for conducting systematic scoping reviews, JBI Evidence Implementation, 13, pp. 141, (2015), DOI: https://doi.org/10.1097/XEB.0000000000000050
16. Grant M.J., Booth A.: A typology of reviews: an analysis of 14 review types and associated methodologies, Health Info Libr J, 26, pp. 91–108, (2009), DOI: https://doi.org/10.1111/j.1471-1842.2009.00848.x
17. Arksey H., O'Malley L.: Scoping studies: towards a methodological framework, International Journal of Social Research Methodology, 8, pp. 19–32, (2005), DOI: https://doi.org/10.1080/1364557032000119616
18. Thomas D.R.: A general inductive approach for analyzing qualitative evaluation data, American Journal of Evaluation, 27, pp. 237–246, (2006), DOI: https://doi.org/10.1177/1098214005283748
19. Zygiaris S.: Smart city reference model: Assisting planners to conceptualize the building of smart city innovation ecosystems, Journal of the knowledge economy, 4, pp. 217–231, (2013), DOI: https://doi.org/10.1007/s13132-012-0089-4
20. de Oliveira Á., Campolargo M., Martins M.: Constructing human smart cities Smart Cities, Green Technologies, and Intelligent Transport Systems, pp. 32–49, Springer (2015), DOI: https://doi.org/10.1007/978-3-319-27753-0_3
21. de Oliveira A.D.: The human smart cities manifesto: A global perspective Human smart cities, pp. 197–202, Springer (2016), DOI: https://doi.org/10.1007/978-3-319-33024-2_11
22. Caputo F., Walletzky L., Štepánek P.: Towards a systems thinking based view for the governance of a smart city's ecosystem: A bridge to link Smart Technologies and Big Data, Kybernetes, 48, pp. 108–123, (2019), DOI: https://doi.org/10.1108/K-07-2017-0274
23. Spinosa L.M., Costa E.M.: Urban Innovation Ecosystem & Humane and Sustainable Smart City: A Balanced Approach in Curitiba, Handbook of Smart Cities, pp. 1–23, (2020), DOI: https://doi.org/10.1007/978-3-030-15145-4_15-1
24. Carayannis E.G., Campbell D.F.J.: "Mode 3" and "Quadruple Helix": toward a 21st century fractal innovation ecosystem, International Journal of Technology Management, 46, pp. 201–234, (2009), DOI: https://doi.org/10.1504/IJTM.2009.023374
25. Etzkowitz H., Leydesdorff L.: The Triple Helix -- University-Industry-Government Relations: A Laboratory for Knowledge Based Economic Development, https://papers.ssrn.com/abstract=2480085, (1995)
26. Leydesdorff L.: Triple Helix of University-Industry-Government Relations in Carayannis, E.G. (ed.) Encyclopedia of Creativity, Invention, Innovation and Entrepreneurship, pp. 1844–1851, Springer, New York, NY (2013), DOI: 10.1007/978-1-4614-3858-8_452
27. Preece J.: Learning Cities as Community Engagement University Community Engagement and Lifelong Learning, pp. 97–122, Springer (2017), DOI: https://doi.org/10.1007/978-3-319-56163-9_5

28. UNESCO: Key features of learning cities, UIL (UNESCO Institute for Lifelong Learning), In UNESCO, International conference on learning cities. Lifelong learning for all: Inclusion, prosperity and sustainability in cities, (2013)
29. McKenna H.P.: ReThinking learning in the smart city: Innovating through involvement, inclusivity, and interactivities with emerging technologies Smarter as the New Urban Agenda, pp. 87–107, Springer (2016), DOI: https://doi.org/10.1007/978-3-319-17620-8_5
30. McKenna H.P.: Adaptability and Attuning in Smart Cities: Exploring the HCI Grand Challenge of Learning and Creativity International Conference on Human-Computer Interaction, pp. 431–442 (2020)
31. McKenna H.P.: Learning and Data in Smart Cities, Seeing Smart Cities Through a Multi-Dimensional Lens, pp. 63–79, (2021), DOI: https://doi.org/10.1007/978-3-030-70821-4_5
32. Schuurman D., Baccarne B., Marez L.D., Veeckman C., Ballon P.: Living Labs as open innovation systems for knowledge exchange: solutions for sustainable innovation development, International Journal of Business Innovation and Research, 10, pp. 322–340, (2016), DOI: https://doi.org/10.1504/IJBIR.2016.074832
33. Layte M., Ravet S.: Rethinking quality for building a learning society Handbook on quality and standardisation in e-learning, pp. 347–365, Springer (2006), DOI: https://doi.org/10.1007/3-540-32788-6_23
34. Mayangsari L., Novani S.: Multi-stakeholder co-creation analysis in smart city management: an experience from Bandung, Indonesia, Procedia Manufacturing, 4, pp. 315–321, (2015), DOI: https://doi.org/10.1016/j.promfg.2015.11.046
35. Costales E.: Identifying sources of innovation: Building a conceptual framework of the Smart City through a social innovation perspective, Cities, 120, pp. 103459, (2022), DOI: https://doi.org/10.1016/j.cities.2021.103459
36. Crossan M.M., Lane H.W., White R.E.: An organizational learning framework: From intuition to institution, Academy of management review, 24, pp. 522–537, (1999), DOI: https://doi.org/10.5465/amr.1999.2202135
37. Petersen S.A., Dahl T.L., Seim E.A., Skogen M.: Enhancing Learning and Collaboration in Organisations through In-house Crowdsourcing Norsk IKT-konferanse for forskning og utdanning (2021)
38. Carayannis E.G., Campbell D.F.J.: Triple Helix, Quadruple Helix and Quintuple Helix and How Do Knowledge, Innovation and the Environment Relate To Each Other?□: A Proposed Framework for a Trans-disciplinary Analysis of Sustainable Development and Social Ecology, IJSESD, 1, pp. 41–69, (2010), DOI: https://doi.org/10.4018/jsesd.2010010105
39. Lodewijckx I.: The difference between citizen engagement and participation, https://www.citizenlab.co/blog/civic-engagement/what-is-the-difference-between-citizen-engagement-and-participation/