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Article

A typology of urban knowledge sharing: from a systematic literature review to an integrated model

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This paper provides insight into how the conceptualization of *urban knowledge sharing* has developed. Based on a structured review and categorization of the literature, we identify three forms of knowledge sharing in and between cities that are distinctly different: *knowledge transfer, knowledge exchange*, and *knowledge co-creation*. We find that the three forms have different boosts and barriers, whereby the complexities of knowledge sharing and hence the capacities required of the actors are lowest for knowledge transfer and highest for knowledge co-creation. We would therefore like to qualify the recent emphasis given in literature to co-creation; with its complexities and required capacities, it is not to be considered a panacea for solving all urban problems. We propose a model within which knowledge transfer and exchange are more suitable for less wicked problems and may sometimes fruitfully reduce complexities.

Keywords: knowledge co-creation; urban knowledge transfer; urban knowledge exchange; learning; urban.

1. Introduction

In an increasingly globalizing and urbanizing world, the urban environment is the center stage of complex development processes, whereby societal challenges have an increasingly wicked and multi-faceted character (Alford and Head 2017). As most of the world population lives in urban areas, developing, adapting and spreading knowledge on sustainable urban development is crucial (Stone et al. 2020) in achieving the sustainable development goals (SDGs) of the United Nations. Academic attention towards understanding and managing knowledge processes has been growing in the last decades. This resulted in many descriptions and conceptualizations of the phenomenon, with important conceptualisations on knowledge transfer (Berg et al. 2012; Ncoyini and Cilliers 2020), knowledge exchange (O'Hagan and Green 2002; Finnegan and Willcocks 2006; Valkering et al. 2013; Hazir and Autant-Bernard 2014; Johnson, Grove, and Clarke 2018), knowledge sharing (Finnegan and Willcocks 2006; Del Giudice, Della Peruta, and Maggioni 2015), joint learning (Angehrn 2012; Azizi 2017), and dissemination (Monnard et al. 2021; Stone et al. 2020; Gagnon 2011; Knott and Wildavsky 1980). The recent concepts knowledge co-creation and co-production took it a step further by describing how knowledge is actively being created (Campbell, Svendsen, and Roman 2016).

As the body of literature is growing, so is the complexity of the terminology, resulting in a myriad of (often overlapping) approaches, definitions, and conceptualizations of knowledge processes. In this paper, we aim to provide an overview of these developments and to propose a conceptual model that can be used to further understand and manage knowledge processes for urban sustainable development. To do so, we raise three research questions: (1) which types of knowledge sharing are identified in literature? (2) what conditions are attached to each form of knowledge sharing? and (3) how can we improve knowledge sharing processes by combining the various types?

Through a literature review, we identify knowledge transfer, knowledge exchange, and knowledge co-creation as overarching categories of knowledge sharing and propose a conceptual framework of problem types, knowledge flows, and conditions for each category. We propose a research agenda to further develop the model and the tools and mechanisms needed to accelerate our mutual efforts toward achieving the SDGs.

2. Background

This section defines the umbrella concepts of knowledge and urban knowledge sharing and key words used in the literature review.

2.1 Defining knowledge

According to the Cambridge dictionary, knowledge is: "understanding of or information about a subject that you get by experience or study, either known by one person or

by people generally" (Knowledge 2021, March 10th). This definition raises the question how information differs from knowledge. Ramdhania (2012 in Ncoyini and Cilliers 2020) argues that "information is the result of processed and structured data, and it can be transferred into knowledge by means of connections, comparisons, conversations and consequences. Knowledge derives from information, which is anchored in the beliefs, views and obligations of its holders." Knowledge gives meaning to information within a specific local context. It is often known subconsciously and gained through experience, held in someone's head. Information, by contrast, is explicit and generalizable: it is clear, structured, codified, and accessible (Nonaka 1994; Leonard and Sensiper 1998; Bhutta and Huq 1999; Hunt and Shackley 1999). Information can be shared relatively easily, but before it can be applied locally, a person or group of persons must attach the meaning. This entails a process of acquiring information, assimilating it, and adjusting it to the local context (Zahra and George, 2002). In our perspective, this process of knowledge absorption is part of knowledge sharing as a process, whereas we define knowledge as its tacit and locally applicable outcome.

2.2 Defining urban knowledge

This article focuses on *urban* knowledge, because the great challenges of our time, ranging from climatic change to unequal access to resources and beyond, are exacerbated in cities. Second, cities, with their heterogeneity, complex networks of relationships and a great variety of governance systems and mechanisms, provide a specific social characteristic that makes the inquiry into urban knowledge processes highly interesting and relevant (Angehrn, 2012).

The conceptualization of urban knowledge has changed dramatically over time. In the 20th century, standardized infrastructure and services were considered sufficient, resulting in a focus on codified urban *information* (as opposed to knowledge) and standardized urban planning models (such as the garden city or Le Corbusier's Ville Radieuse; Bettencourt 2013; Bertaud 2021). In the 1980s, New Public Management replaced standardized urban planning, as one realized that every city is unique and requires contextualized, local application of information (Fransen, Van Dijk, and Edelenbos 2021). Nowadays, cities are seen as complex systems, facing wicked challenges like climate change or drug wars that cannot be solved independently from other urban problems (Tonkinwise 2015; Alford and Head 2017). The sustainability challenges addressed by the SDGs represent such wicked problems. In practice, the framing of urban sustainability problems as well as the selection of relevant knowledge and solutions, is inherently political. This leads to an unequal playing field. At the local level, expert knowledge is often prioritized over localized indigenous knowledge (Briggs, 2005). On an international scale, the hegemony of Northern cities in academic research leads to inappropriate solution and problem framing of Southern academics and cities (Patel 2014; Nagendra et al. 2018). Here, we argue—in line with critical urban theory—that all types of urban knowledge by all actors are equally valuable for a socially just and sustainable form of urbanization (Brenner 2009), including both expert-based and praxis-based knowledge (Briggs, 2005; Petersén and Olsson 2015). Instead of just applying and contextualizing external knowledge, the most recent view on urban knowledge is that we should combine external information with local, tacit knowledge to become applicable.

Taking the above sections on board, we define urban knowledge as diverse forms of information by multiple actors about an urban (tame of wicked) problem and its potential solutions, which is applicable within a specific local urban environment and takes related (wicked) problems into account.

2.3 Defining urban knowledge sharing

Scholars often use knowledge sharing, diffusion, transfer, and dissemination synonymously or rather loosely. We use knowledge sharing as an umbrella concept, which encompasses processes within which urban actors give data, information, or knowledge to other urban actors, who turn it into knowledge which is locally applicable. The transformation from data to information to knowledge (Ncoyini and Cilliers 2020), includes adjusting information to a local context; a process which is highly political. This process always creates new knowledge, if only because it leads to another way of applying already existing knowledge from another context. These new findings may in turn benefit the original sender. Especially for complex urban problems, the process of knowledge sharing becomes nonlinear and non-deterministic, because it combines and integrates multiple and multidisciplinary data, information, and knowledge within a new and unique local context. It turns into a process of knowledge co-creation, defined as "the practice of collaborative product or service development: where developers and stakeholders are working together" (Mahmoud and Morello 2021: 262). In our perspective, however, product or service development is not a prerequisite for knowledge co-creation. One can also meaningfully co-create knowledge, agreeing on what a specific problem entails or deciding that no new product or service is needed.

We therefore define urban knowledge sharing as iterative processes of sending, receiving and/or collaboratively combining and (re)developing diverse forms of information by multiple actors about urban (tame or wicked) problems and their potential solutions with tacit knowledge experiences within complex urban environments.

3. Methods

The existing literature was systematically mapped through a hybrid literature review. This combines the advantages of transparency and replicability of a systematic literature review (Okoli 2015) with a descriptive scoping review (Xiao and Watson 2019) to serve the two-sided objective of this study to map the field and to propose a conceptual synthesis.

3.1 Data collection

We used a search string containing keywords that capture the "what, where and how" of urban knowledge sharing, the search words "knowledge" and "urban" capture the "what" and "where." Since the process is referred to in various ways, we included "transfer," "diffusion," "exchange," "co(-)production," and "co(-)creation." Articles on what we call knowledge sharing generally use at least one of these terms to describe the process. Each term has its own nuances, whereby transfer and diffusion often focus on disseminating

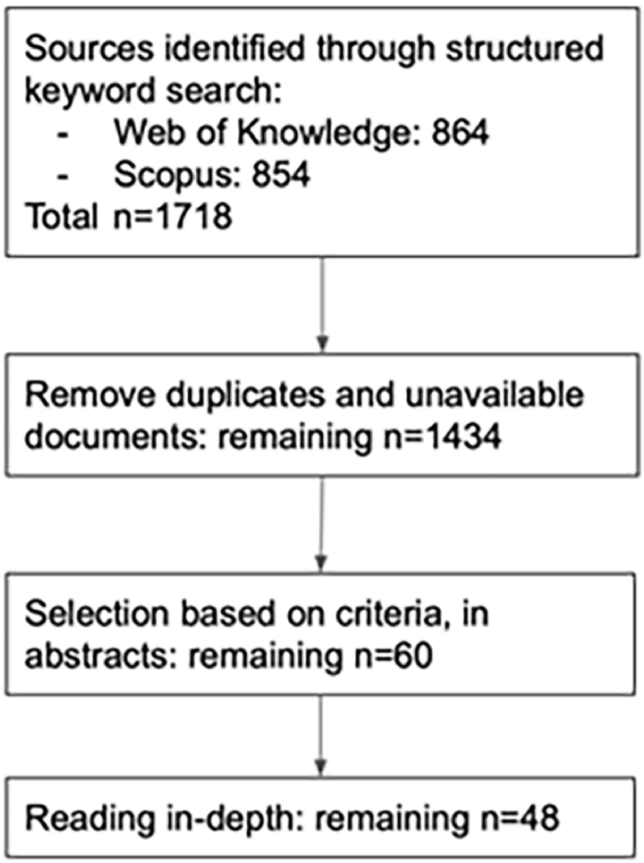

Figure 1. Flowchart of item selection.

information (Knott and Wildavsky 1980; Glaser et al. 2020), exchange typically takes place in a network of experts or supply chains (De Jong and Edelenbos 2007; Verwaal 2017, Minkman et al. 2018), while co-creation and co-production are relatively new concepts used to tackle complex problems in a more holistic and heterogeneous way. Both pay attention to the development process and resulting product, but co-production emphasizes the process of how a situation is approached (Van der Hel 2016), while co-creation emerged in business literature and takes the aim of developing a product as a starting point (Mahmoud and Morello 2021: 262).

We added keywords to filter items that discuss what stimulated and hindered knowledge transfer. These search terms are considered sufficient to identify a list of studies that is complete enough and suitable to answer the review question (Xiao and Watson 2019).

The terms "inclusive," "exclusive," "learning," and "absorptive capacity" were also considered but excluded. A quick scan showed that "learning" significantly increased the amount of noise (i.e. ineligible items) and that all relevant items mentioning "inclusive" processes could also be identified by the keywords co-creation and co-production. Absorptive capacity is the "change-oriented dynamic capacity" (Zahra and George 2002) and was excluded because it is a condition for knowledge sharing rather than a concept describing the process itself.

We entered the query in the multidisciplinary electronic databases Web of Science and Scopus. From 1718 documents, duplicates, unavailable documents, and non-English items were removed. To be included, studies had to be peer-reviewed and conceptual or empirical in nature. Studies focusing on technologies for knowledge sharing, pedagogical questions or medical or neurobiological aspects were excluded. Based on abstracts, 60 documents seemed eligible. Another seventeen items were excluded as they failed to meet the criteria during a full-text read. Figure 1 visualizes the described process that led to the forty-eight items included in the review.

3.2 Data analysis

Query results were stored in EndNote and the articles were subsequently coded. Codes focused on four aspects: "urban problem," "definition of sharing," "process characteristics," and "conditions for effective knowledge sharing." Conditions were only extracted from the results, discussion, and conclusion sections. A condition was broadly defined as anything affecting the outcome or process of knowledge sharing. We deliberately refer to these as conditions, as stimulating factors may become barriers when being absent and vice versa. Creating sub-codes for the conditions was done iteratively, taking the conditions in the framework of Gul and Jamal (2020) as sensitizing concepts. In later iterations, codes were added, merged, split, or removed when appropriate. We added organizational culture; language; equality; process

Table 1. Conditions for knowledge sharing.

Group	Conditions	Number of times mentioned Transfer	Exchange	Co-creation	Total
Actors	Organizational culture	15	10	6	31
	Ability to share	8	8	9	25
	Willingness to learn		1	6	7
	Experience	2	2	–	4
	Motivation	1	1	2	4
	Absorptive capacity	1	–	–	1
	Cognition	1	–	–	1
Knowledge types	Ambiguity	2	2	1	5
	Tacit/explicit	1	2	–	3
Relationship	Process management/approach				25
	Direct relations & intensity of connection	7	12	5	24
	Equality	2	4	15	21
	Language	3	5	7	15
	Trust	2	6	6	14
	Evaluation	2	2	8	12
	Monitoring	–	1	4	5
	Communication	–	1	2	3

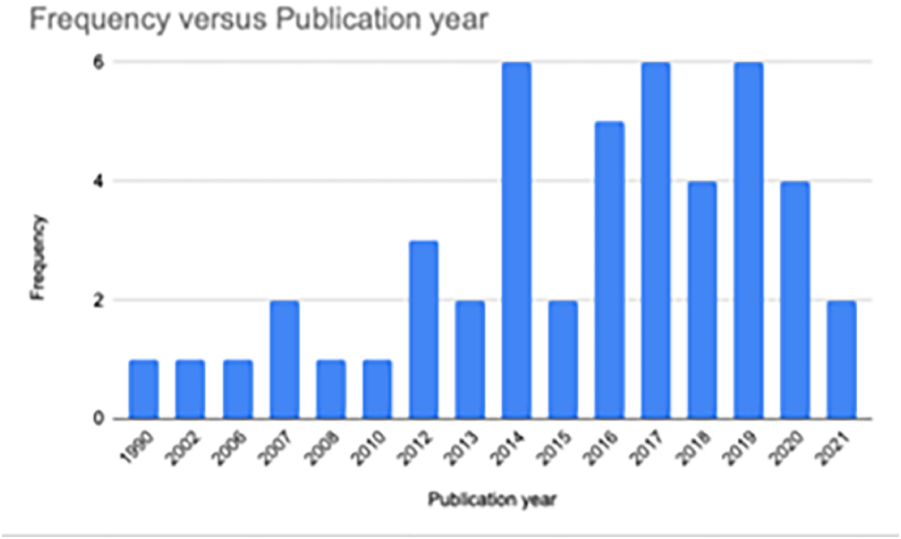

Figure 2. Publication years.

management; monitoring and evaluation, see Table 1. Following Gul and Jamal (2020), we group the conditions into those related to the actors, type of knowledge and relationship. Narratives for the three main categories of knowledge are based on the coded articles and are presented in Section 4.2.

4. Results

After presenting descriptive results of the literature (Section 4.1), we introduce three types of knowledge sharing with their own definitions, problems addressed, processes and perceived conditions (Section 4.2). Section 4.3 proposes an integrated model for the process of knowledge sharing.

4.1 General results

The forty-eight articles have mainly been published in the last four decades, with most publications from 2010 onwards (Fig. 2). They focus on contemporary urban challenges and on wicked urban problems, such as environmental and sustainability issues. They are published in a wide range of journals, some targeting a wide range of disciplines and themes (e.g. *Cities* or the *Journal of Knowledge Management*), while we also observed a concentration in environmental and sustainability journals.

Despite major differences in the description of the processes of knowledge sharing between the articles, there is considerable overlap in their conditions for success. These conditions are clustered in three groups summarized in Table 1 and defined further.

The first group of conditions concerns "actors." Actor roles are often discussed separately for knowledge transfer (i.e. sender versus receiver), while no such distinction is made for knowledge exchange and co-creation. Within this group, the condition "organizational culture" is not only mentioned most often but also is broad and ambiguous at times, with a broad range of sub-conditions (see Table 1) that affect the process directly or indirectly. Pham and Dinh refer to organizational culture as the "spiritual and physical environment of an organization that determines the attitude and behavior of its members" (2020: 396). It includes values and beliefs and how this works through an organization such as the extent

to which space is created for new ideas. An important aspect of the organizational culture is the management support and commitment to knowledge sharing (Finnegan and Willcocks 2006; Tong and Jingyuan 2010; Hegger, Van Zeijl-Rozema, and Dieperink 2014; Munoz-Erickson 2014; Azizi 2017; Johnson, Grove, and Clarke 2018; Kane and Boulle 2018; Menny, Voytenko Palgan, and McCormick 2018; Ncoyini and Cilliers 2020).

"Ability to share" is mentioned twenty-five times and refers to the practical conditions for knowledge sharing. It includes sub-conditions such as availability of resources, two of the most important being time and funding (Hegger, Van Zeijl-Rozema, and Dieperink 2014; Guentner and Harding 2015; Stollmann 2016; Trencher et al. 2017; Geldin 2019; Magnussen, Dalby Hamann, and Gro Stensgaard 2019; Monnard et al. 2021). Also, timing of the knowledge flow is important and was found to be important for both knowledge exchange and co-creation (Greyling, Patel, and Davison 2017; Martins and Ling 2017; Johnson, Grove, and Clarke 2018; Menny, Voytenko Palgan, and McCormick 2018). In addition, several authors note that sharing knowledge is in fact a form of "power-sharing" (Campbell, Svendsen, and Roman 2016). Actors that fear losing power or position will not commit to knowledge sharing (Angehrn 2012; Finnegan and Willcocks 2006; Johnson, Grove, and Clarke 2018).

"Willingness to learn" is a condition mentioned mostly for co-creation processes. It requires a necessary degree of openness. A lack thereof, in combination with resistance to change can limit knowledge sharing processes. Willingness can be increased when both knowledge sharing partners experience benefits and prioritize the process.

"Experience" touches on the (internalized) knowledge through practice. For an organization as a whole, this translates to the organizational memory, which is defined as "linking individual perspectives of knowledge to an organizational level" (Berg et al. 2012: 3).

"Motivation" is the willingness of actors to participate in knowledge sharing processes leading to learning and change. For co-creation, this has also been typed as "the will to change" (Stollmann 2016), whereby change is often incremental rather than transformative and radical (Laitinen, Osborne, and Stenvall 2016; Teirlinck 2018; Gebhardt, Brost, and Konig 2019; Pham and Dinh 2020; Monnard et al. 2021). Motivation to learn and change is required at multiple levels, ranging from individuals to departments and organizations as a whole, and thus can have a far-reaching impact (Angehrn 2012; Laitinen, Osborne, and Stenvall 2016; Trencher and Bai 2016; Kane and Boulle 2018; Magnussen, Dalby Hamann, and Gro Stensgaard 2019; Ncoyini and Cilliers 2020). A personal or organizational resistance to change can impede the knowledge sharing process significantly.

"Willingness to share" reflects the openness to share knowledge, which may be perceived as private. It is optimized by the presence of mutual benefits for all involved actors (Magnussen, Dalby Hamann, and Gro Stensgaard 2019). It is a reflection of the openness of the sender towards the process. The conditions of "absorptive capacity" and "cognition" were found only once. Absorptive capacity is defined by Cohen and Levinthal as "the ability to recognize, adapt and apply the newly acquired knowledge" (Obermeyer 1990, as cited by Gul and Jamal 2020). The conditions respectively indicate the ability of an actor or organization to receive the knowledge being transferred (Berg et al. 2012).

The second group of conditions concerns the knowledge types. "Knowledge ambiguity" expresses the relative lack of coherence between the sources and components of knowledge within differing contexts (Khirfan, Momani, and Jaffer 2013; Guentner and Harding 2015; Laitinen, Osborne, and Stenvall 2016; Johnson, Grove, and Clarke 2018). This is related to the nature of knowledge, the second dimension in this group. When knowledge is of tacit nature and/or praxis-based, it is more difficult to share than the explicit- and expert-based knowledge (Berg et al. 2012; Johnson, Grove, and Clarke 2018; Bickel et al. 2020).

The third group, on the relationship between actors, is most often discussed. The condition discussed most is that of *process management*. Whereas scholars agree on the need for a level of flexibility, there is debate about the need for clear objectives, guidelines, protocols, and a division of responsibilities. Such conditions may increase efficiency and accountability but may also function as a straight jacket, reducing openness, flexibility, and out-of-the-box thinking.

A second condition in this group is the directness of relations and the intensity of the connection between the knowledge sender and receiver. Sub-conditions include face-to-face contact (Berg et al. 2012; Teirlinck 2018), informal meetings or connections (Finnegan and Willcocks 2006; Angehrn 2012; Del Giudice, Della Peruta, and Maggioni 2015; Campbell, Svendsen, and Roman 2016; Geldin 2019; Bickel et al. 2020), geographical distance (Martins and Ling 2017; Dabrowski, Varju, and Amenta 2019), personal relations (Khirfan, Momani, and Jaffer 2013; Kane and Boulle 2018), and frequency of meetings (Teirlinck 2018).

The third condition "equality" applies to organizations as well as individuals involved in a knowledge exchange process (Angus et al. 2008; Van Ewijk 2012; Stollmann 2016; Chammas et al. 2020). Sub-conditions include inclusivity of all actors, equal power relations, reciprocity, loyalty, and awareness to a possible social bias (Campbell, Svendsen, and Roman 2016; Dabrowski, Varju, and Amenta 2019), also named "crisis of representation" (Geldin 2019). Actors with (formal) power determine who gets access to the knowledge sharing space (Guentner and Harding 2015; Greyling, Patel, and Davison 2017) and determine what knowledge is worth sharing (Foth, Odendaal, and Hearn 2007).

Singled out as a unique sub-condition is language. This condition can be interpreted and implemented in multiple ways, of which the most self-evident is the actual language being spoken (Guentner and Harding 2015; Teirlinck 2018; Dabrowski, Varju, and Amenta 2019; Gebhardt, Brost, and Konig 2019; Geldin 2019; Pham and Dinh 2020). However, language is also indicated by a shared disciplinary background, whereby a specific jargon eases understanding (Angehrn 2012; Valkering et al. 2013; Kane and Boulle 2018; Nikulina et al. 2019). If the need for translation emerges, interpretation can hinder the knowledge sharing process.

The condition "trust" is actively created and supported in combination with other conditions and enables the willingness to freely share knowledge (Tong and Jingyuan 2010; Campbell, Svendsen, and Roman 2016; Laitinen, Osborne, and Stenvall 2016; Ncoyini and Cilliers 2020). Conditions such as face-to-face contact contribute to trust base (Berg et al. 2012). We added "monitoring" and "evaluation" as

conditions, which include the (continuous) documentation (Gebhardt, Brost, and Konig 2019), publication, and communication of the knowledge sharing results and the ability to keep up to date (Berg et al. 2012; Hegger, Van Zeijl-Rozema, and Dieperink 2014; Trencher et al. 2017; Ramsey et al. 2019; Pham and Dinh 2020) or the knowledge circulated (Cabitza, Cerroni, and Simone 2014). This condition is closely interwoven with process management.

Finally, "communication" is a multi-faceted condition (Johnson, Grove, and Clarke 2018). It can be defined as the means of sending or receiving information. This condition includes communication infrastructure (Hazir and Autant-Bernard 2014), openness in communication (Martins and Ling 2017), and direct and targeted communication (Ramsey et al. 2019; Pham and Dinh 2020).

4.2 Three types of knowledge sharing

From the analysis, we identify three types of knowledge sharing, based on the "direction" of knowledge. We label these archetypes as (1) knowledge transfer (one-way knowledge sharing), (2) knowledge exchange (two-way knowledge sharing) and (3) knowledge co-creation (generating new knowledge). Given the inconsistency in the use of terminology in literature, our categorization may differ from the terms used by the authors, for example Hegger, Van Zeijl-Rozema, and Dieperink (2014) and Khirfan, Momani, and Jaffer (2013). We present the three archetypes by focusing on the actors, their relations, the problems addressed, and the characteristics of the knowledge that is shared.

4.2.1 Urban knowledge transfer. Scholars define knowledge transfer in different ways. Del Giudice, Della Peruta, and Maggioni (2015: 612) define it as the "transmission of a message from a source to a recipient in a particular setting." This definition emphasizes the linear process, whereby one side with advanced knowledge (the sender) offers knowledge to a less knowledgeable side (the receiver). A guideline on community participation in water supply of the urban poor offers a linear process of knowledge transfer, even though its implementation is far from linear. Knowledge transfer on urban challenges is however more ambiguous and complex than the linear process depicts (Berg et al. 2012). Feedback loops arise when the receiver starts questioning how to apply knowledge in a different context. Differences in cultural contexts (Gantner 2017) and limited organizational capacities (Ncoyini and Cilliers 2020) challenge the effectiveness of linear knowledge transfer models (Pham and Dinh 2020). The line between linear knowledge transfer and nonlinear knowledge exchange becomes thin. This is reflected in Table 2, which labels the variety of definitions.

Urban issues addressed in knowledge transfer are often related to a single sector and can be classified as tame and tractable (i.e. actors have developed a way to deal with those). This type of knowledge transfer is commonly used, for instance, when googling for guidelines on the design of landfills or processes of community mapping. In these cases, the knowledge shared is mostly explicit in nature. The transfer can take place at different levels: within organizations and projects, between organizations and projects at urban, regional, or (inter)national level, and by consulting books, Internet, and other sources of information. Knowledge transfer between Northern and Southern urban managers is looked at critically from the perspective of neo-colonialism, pinpointing at power imbalances (Patel 2014; Nagendra et al. 2018).

Table 2. Knowledge transfer definitions.

- "Process where ambiguous and complex routines are reconstructed and stored in a way that they can be adapted and used in future projects" (Berg et al. 2012: 2)
- "Process through which one unit (e.g. group, department, or division) is affected by the experience of another" (Dabrowski, Varju and Amenta 2019: 53)
- "Transmission of a message from a source to a recipient in a particular setting. Moreover, the message or the situation could have certain features, limiting the quantity of transferable knowledge, which may result in a stickier transfer" (Del Giudice, Della Peruta and Maggioni 2015: 612)
- "Process consisting of numerous components and changes that go beyond the mere description of its originating culture, the transmitting actors, or the target culture" (Gantner 2017: 603)
- "Contribution of knowledge by the organization and the collection, application and assimilation of knowledge by employees" (Ncoyini and Cilliers 2020: 2)
- "An important step of the knowledge management process, in which one or both parties seek and give their knowledge, especially their tacit knowledge (know-how, attitude, experience, ideas.) (…) It focuses more (…) the effectiveness of this behavior, especially from the knowledge receiver's viewpoint" (Pham and Dinh 2020: 396)

Taking the above into account, we define urban knowledge transfer as the complexified transmission of knowledge from a source to a recipient on relatively tame urban problems, whereby complexities refer to feedback loops and effectiveness issues due to cultural differences, power imbalances, and organizational capacities.

Figure 3 depicts the process of knowledge transfer and its conditionalities. The quality of the interactions between sender and receiver may be characterized as a teacher–apprentice relationship where one actor holds significantly more knowledge than the other. The main condition thereby relates to the senders' ability to share knowledge considering available resources and access to information (Table 1). The second condition is organizational cultures that are open to share knowledge. At the receiving end, this relates to an open attitude to new knowledge (Berg et al. 2012), a willingness to learn (Khirfan, Momani, and Jaffer 2013) and an ability to perceive the usability of the received knowledge (Pham and Dinh 2020). The degree of willingness to learn is associated with a "friendly culture" (Pham and Dinh 2020) as opposed to public opposition (Dabrowski, Varju, and Amenta 2019) to new knowledge. Despite this attention to the capacities needed at the receiving end, the concept of (absorptive) capacity is not explicitly addressed in articles we studied.

The knowledge type for transfer is mainly codified and unambiguous. Knowledge which is codified based on experiences in one city is not always compatible with the context in another city. This is in line with the argument that knowledge transfer is especially applicable for tame and tractable problems.

4.2.2 Urban knowledge exchange. The second type of knowledge sharing is knowledge exchange, which Valkering et al. (2013: 86) define as "the process of exchanging 'established' knowledge between actors." In knowledge exchange,

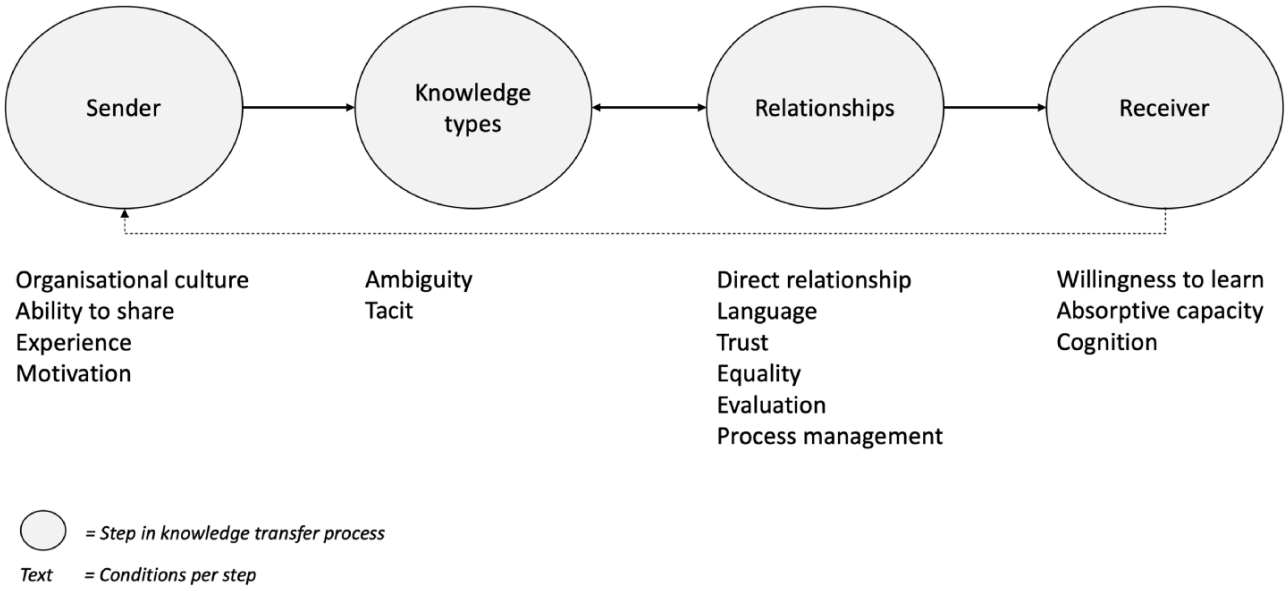

Figure 3. Process and conditions of knowledge transfer.
Source: adapted from (Gul and Jamal, 2020).

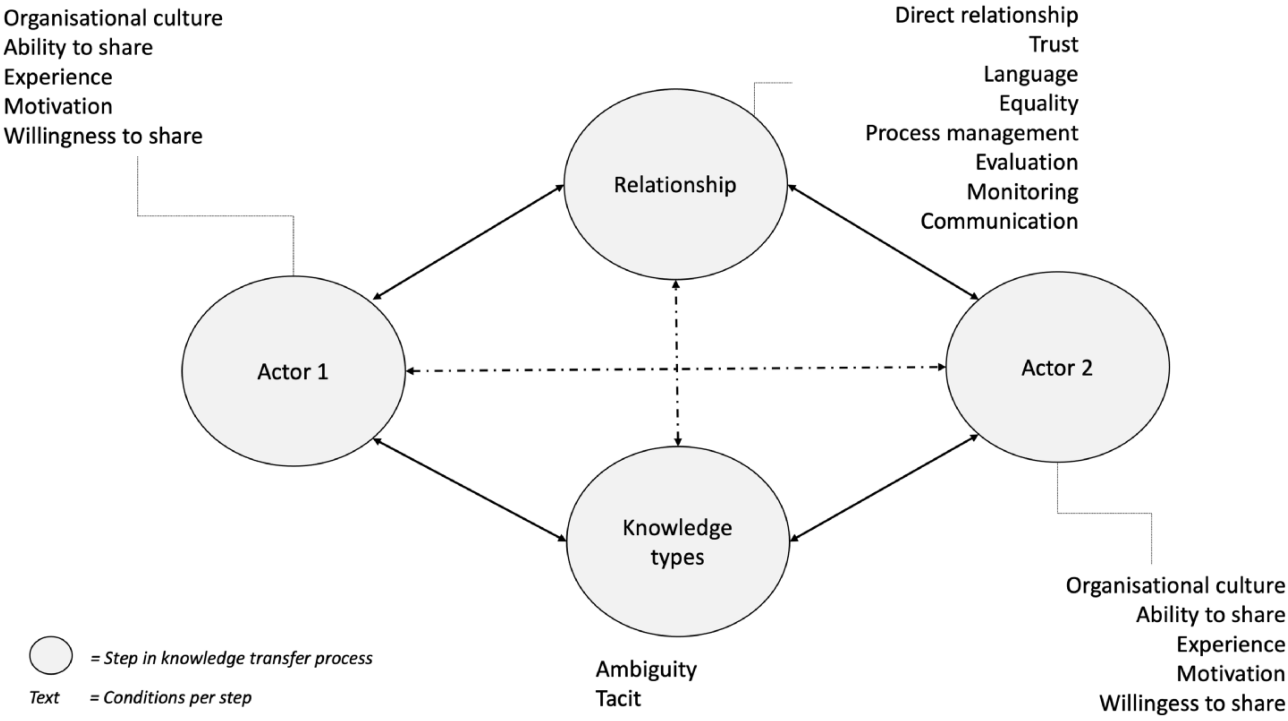

Figure 4. Process and conditions of knowledge exchange

equally knowledgeable parties share knowledge, whereby each sends and receives knowledge. Johnson, Grove, and Clarke (2018: 2) view knowledge exchange more broadly as "collaborative problem solving (...) that happens through linkage and exchange." Joint problem-solving includes the transformation from data to information to knowledge applicable in local contexts (Ncoyini and Cilliers 2020). This process thus includes the adjustment of established knowledge to locally applicable knowledge.

Knowledge exchange is suitable for addressing wicked urban problems, which cut across sectors and disciplines, such as how to improve urban competitiveness (Tong and Jingyuan 2010), how to engage vulnerable communities into transition processes (Martins and Ling 2017) and how to

Table 3. Definitions of knowledge exchange.

— "Collaborative problem solving between researchers and decision makers that happens through linkage and exchange" (Johnson, Grove and Clarke 2018).
— "Dynamic and fluid process which incorporates distinct forms of knowledge from multiple sources" (Ward et al. cited by Johnson, Grove, and Clarke 2018: 2)
— "Process of exchanging 'established' knowledge between actors" (Valkering et al. 2013: 86)

Table 4. Definitions for knowledge co-creation.

- "How broader social, cultural, and political factors shape and are shaped by the production of scientific knowledge, policy, and practice" (Campbell, Svendsen, and Roman 2016: 1263)
- "Joint production of a service with the state where one or more elements of process are shared" (Kane and Boulle 2018: 1184)
- "Active engagement of citizens in collaboration with other partners, at least equal power to influence" (Menny, Voytenko Palgan, and McCormick 2018)
- "Supports the involvement of a broad range of stakeholders, most important, community-members, as collaborators and drivers of the research and disseminations process" (Monnard et al. 2021: 216)
- "Mutual construction between knowledge and forms of social organization. In other words, co-production is concerned with the macro societal processes that shape and are shaped by the production of knowledge" (Munoz-Erickson 2014: 183)
- "Role where the university collaborates with diverse social actors to create societal transformations in the goal of materializing sustainable development in a specific location, region or societal-sub sector" (Trencher et al. 2017: 2)

stimulate research & development in addressing urban challenges (Hazir and Autant-Bernard 2014; Teirlinck 2018). Compared to knowledge transfer, knowledge exchange is more likely to bank on tacit, indigenous, and praxis-oriented knowledge, as it is impossible for codified knowledge to describe all components and interlinkages of wicked problems. As a result, the process places emphasis on joint learning within cities.

Compared to knowledge transfer, the process is more complex and therefore non-linear and less deterministic, see Figure 4. In the process, the sender becomes a receiver and vice-versa. The relationship is characterized by knowledge moving in both directions, whereby knowledge is adjusted and contextualized in iterative processes. The process takes multiple forms, including learning-by-playing, municipal networks, bilateral collaboration, field visits, e-mail contact, and cross-regional research & development collaboration.

Based on multiple definitions described in Table 3, we define urban knowledge exchange as the nonlinear reciprocal process to share established knowledge among multiple actors and in multiple forms, and incrementally adapt it to address complex urban problems in urban contexts.

In such a more complex process, the academic debate on conditions changes. The condition discussed most often is that of a high-quality direct relationship, based on ties of trust and equality, whereby actors speak the same language both literally and figuratively. The ability to share has a similar significance as for knowledge transfer, but the emphasis shifts to the organizational, social, and political barriers in translating and adapting knowledge between contexts. These most discussed conditions are crucial in sharing tacit, expert-based, and indigenous knowledge, as well as understanding and appreciating each other's context.

The complex interactions also raise organizational requirements and issues of power imbalances. All actors have unique knowledge that can be considered and assessed, but this knowledge is not always equally heard or valued. Sharing multiple forms of knowledge across multiple actors requires equal relationships based on ties of trust cemented in formal and informal contact. Trusting and valuing each other not only enlarges the willingness to share knowledge but also renders praxis-driven, local, and codified knowledge visible and valuable.

4.2.3 Urban knowledge co-creation. In knowledge co-creation, multiple actors produce new knowledge based on mutually existing knowledge among a varied group of actors. Co-creation, co-production, and co-design are often used interchangeably (Gebhardt, Brost, and Konig 2019). Definitions resulting from the review are divergent, making distinctions in and between which sphere(s) the process takes place (Campbell, Svendsen, and Roman 2016). Transdisciplinarity and the involvement of these spheres are central to most definitions of co-creation (Chammas et al. 2020), but perhaps the most complete definition is the one provided by Munoz-Erickson (2014: 183): "co-production is here understood as the mutual construction between knowledge and forms of social organization. In other words, co-production is concerned with the macro societal processes that shape and are shaped by the production of knowledge." Many definitions stress the involvement of a broad range of stakeholders and in particular, urban community members (Menny, Voytenko Palgan, and McCormick 2018; Monnard et al. 2021) and universities (Trencher et al. 2017) as equal partners in the process. They may take part in one or more of the planning steps (Kane and Boulle 2018). In Table 4, we group the definitions for knowledge co-creation.

Knowledge co-creation is used to derive innovative solutions or policies required to address wicked and complex issues (Chammas et al. 2020). Such issues include those involving multiple sectors and actors—such as in water governance, sustainability, resilience, mobility, urban farming and planning (Campbell, Svendsen, and Roman 2016; Stollmann 2016; Trencher and Bai 2016; Greyling, Patel, and Davison 2017; Trencher et al. 2017; Gebhardt, Brost, and Konig 2019; Nikulina et al. 2019; Ramsey et al. 2019), and also other issues surrounded by uncertainty, like climate change and anticipating future problems (Kane and Boulle 2018; Magnussen, Dalby Hamann, and Gro Stensgaard 2019). In such wicked and complex urban problems, the "broader social, cultural, and political factors shape and are shaped by the production of scientific knowledge, policy, and practice" (Campbell, Svendsen, and Roman 2016). Problem and solution frames from elsewhere are considered irrelevant due to the different local context.

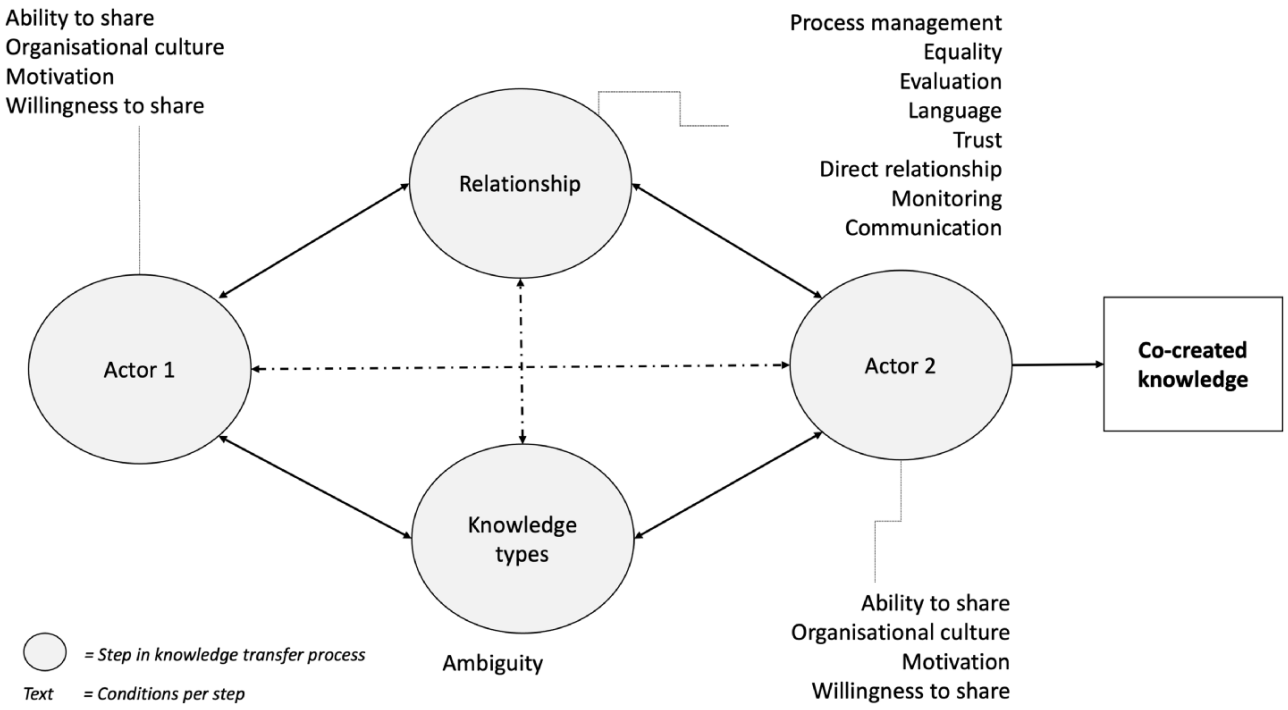

Figure 5. Process and conditions of knowledge co-creation.

Based on the above, we define urban knowledge co-creation as the process of multiple actors to jointly produce new transdisciplinary knowledge based on multiple forms of knowledge to address a specific wicked complex urban problem. This process can take various forms, of which living labs are especially widely discussed. Although processes of knowledge exchange may also implicitly create new knowledge, the explicit objective of knowledge co-creation to deal with a specifically wicked problem, places more emphasis on the process to develop new knowledge that addresses this problem (Fig. 5).

The conditions of co-creation focus on the organizational process and enabling environment. In the organizational process, leadership and process management are widely discussed. Also, the willingness to engage in complex and intense knowledge co-creation processes is emphasized, arguing that processes of co-creation are initiated from a joint objective and thus joint interests.

Specific to literature on co-creation is the attention to monitoring and evaluation. It is the only archetype for which continuous (rather than retrospective) monitoring and evaluation are put forward. This relates to the *ex ante* nature of co-creation studies, while studies on knowledge transfer and exchange are *ex post* studies. The attention to continuous monitoring and evaluation feeds an intensive, multi-directional, and open-ended design process.

Table 5 summarizes the three archetypes and their key characteristics, acknowledging that they represent a continuum rather than distinct categories. The three archetypes have many commonalities, as all share knowledge across multiple actors operating in complex urban settings. However, they differ distinctly in terms of the process, problems they are best placed to address, type of knowledge most easily shared, and core conditionalities. Whereas knowledge co-creation is most suited to address complex problems, it would not be an effective and suitable framework for tame problems. For instance, one would not organize stakeholder meetings for every pothole to be repaired, as this would lead to participation fatigue and an overly influence of the usual suspects engaged in co-creation processes. Instead, we recommend an explicit knowledge sharing process which combines archetypes and instruments (Michaels 2009).

4.3 Towards an integrated and participatory model of knowledge sharing

Co-creating knowledge has gained momentum as attention to wicked problems in cities multiplied. Wicked problems are perceived to represent "intractable masses of complexity, so conflict-prone and/or intractable that they defy definition and solution" (Alford and Head 2017: 397). The growing attention to wicked problems has resulted in the proposition and practice of knowledge co-creation as the single-best approach of knowledge sharing. We agree with Alford and Head (2017) that this single mindedness requires reconsideration, because urban problems represent different levels and forms of wickedness. Michaels (2009) identifies differences in knowledge brokering strategies in addressing different problem types. Similarly, we identify forms of knowledge sharing addressing different types of problems with their own processes and conditionalities, whereby knowledge co-creation is the most intensive process.

We find that literature on knowledge transfer, exchange and co-creation focuses on different conditions. For instance, absorptive capacity and power imbalances are not widely discussed in the articles on knowledge transfer we studied, while these conditions may explain why knowledge is not applicable in another urban context. By the same token, the co-creation literature we studied appears to pay less attention to differences in organizational cultures, while these may influence the

Table 5. Overview of the three types of urban knowledge sharing and their characteristics.

	Knowledge transfer	Knowledge exchange	Knowledge co-creation
Key authors	- Del Giudice, Della Peruta and Maggioni (2015), 62 citations - Hajkova and Hajek (2014): 34 - Khirfan, Momani and Jaffer (2013): 19 - Gantner and Hein-Kircher (2017): 14	- Finnegan and Willcocks (2006): 41 - O'Hagan and Green (2002): 38 - Hazir and Autant-Bernard (2014): 28 - Johnson, Grove and Clarke (2018): 14	- Munoz-Erickson (2014): 82 - Valkering et al. (2013): 55 - Menny, Voytenko Palgan and McCormick (2018): 54 - Campbell, Svendsen and Roman (2016): 48 - Cao et al. (2016): 44
Our definition	The complexified transmission of knowledge from a source to a recipient in a relatively tame urban setting.	The nonlinear reciprocal process to share knowledge and incrementally adapt it to address complex urban problems	The process of multiple actors to jointly produce new transdisciplinary knowledge in order to address a specific wicked complex urban problem.
Process characteristics	One-way process Feedback loops	Two-way process	Two-way process to create new knowledge
Other characteristics	Unequal distribution of knowledge at start; explicit knowledge	Equal knowledge contributions; tacit knowledge	New knowledge based on existing knowledge base Multiple actors bring in relevant knowledge; expanding existing knowledge
Problems addressed	Tame	Complex	Wicked

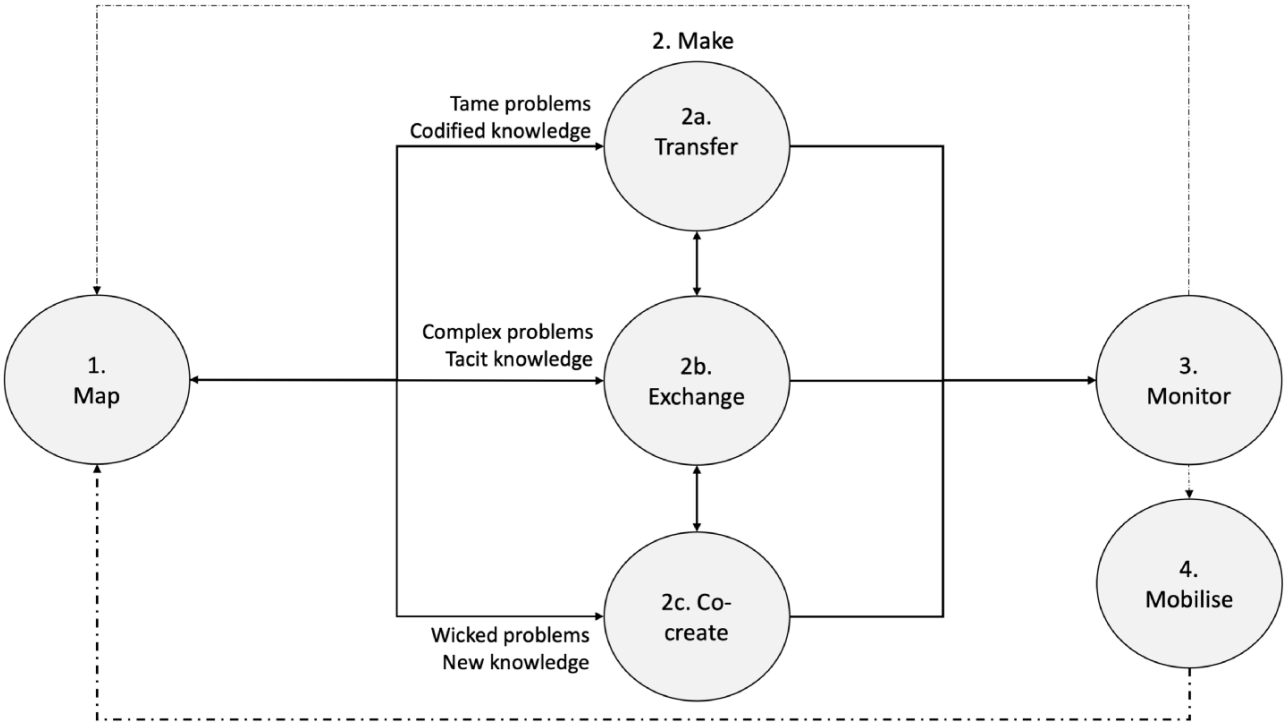

Figure 6. Knowledge sharing process.

ability and willingness for organizations to collaborate. We therefore argue that the three modes of knowledge sharing can learn from each other.

We propose to explore these synergies in an integrated and participatory model of knowledge sharing. By giving explicit attention to knowledge sharing as a process, we first aim to make the process more efficient. Rather than reinventing the wheel in co-creation processes, knowledge transfer and exchange can bring in existing knowledge from elsewhere (Fig. 5). We also aim to develop a model which is inclusive, which values all types of knowledge, including praxis-based and indigenous knowledge (Petersén and Olsson 2015) and acknowledges issues of neo-colonialism, cultural diversity, and power imbalances (Patel 2014; Nagendra et al. 2018). Using our research findings, we recommend an integrated and participatory knowledge sharing process comprising four steps (Fig. 6).

In Step 1 (Map), urban actors frame the problems and map available local knowledge. As knowledge on wicked problems is spread across multiple actors, locations and forms of knowledge, this is no easy feat. Mazzucato (2018) recommends this exercise is best done by partnerships of the willing and able. By contrast, (Briggs, 2005) and Petersén and Olsson (2015) argue it is important to explicitly include praxis-based

and indigenous knowledge. At the same time, policy makers and other powerful players are crucial in moving towards implementation in later stages.

Step 1 makes knowledge sharing explicit. Knowledge sharing is often a byproduct receiving limited attention. We argue that explicitly planning the process visualizes power imbalances and types of knowledge. Knowledge itself is not neutral and especially technology-based interventions may be associated with being male, white, and Western (Foth, Odendaal, and Hearn 2007; Khirfan, Momani, and Jaffer 2013). We recommend a carefully balanced mapping process by exchanging knowledge between the powerful and powerless as well as the willing and unwilling. This asks for a combination of methodologies and openness to ideas, even if these are (politically) uncomfortable (Briggs, 2005).

In Step 2 (Make), a core group of urban actors break wicked problems down into smaller problems. Unbundled problems are likely to represent different levels of wickedness, depending on their complexity, clearness of the problem and solution, and actors involved (Alford and Head 2017). The unbundled problems can be grouped into three categories, roughly labeled as tame, complex, and wicked problems. Tame problems are urban challenges, whose definitions and solutions can be described in codified knowledge. These problems can most efficiently be addressed in knowledge transfer. Sometimes, however, solutions are not available or irrelevant to local contexts, difficult to communicate, or politically unacceptable. Inspiring cases and benchmarks may offer convincing arguments. Problems without a solution at hand as well as complex problems, which are analytically, cognitively, and/or conceptually hard to define and analyze, can be discussed in processes of knowledge exchange. In these processes, the exchange can deepen the understanding of the problem and potential solutions as well as the understanding of political or procedural complexities. Knowledge transfer and exchange thus prevent reinventing the wheel. As in Step 1, however, the reality is that power constructs such as neocolonialism limit the search for knowledge, missing out on less popular and evidenced but possibly more relevant information. Power asymmetry may challenge the initiation of sharing routines and vested political interests may result in support or resistance to sharing knowledge on certain topics Kane and Boulle (2018). To "correct" these power constructs, or if the problems at hand are politically turbulent and/or so wicked that solutions elsewhere defy their purpose, knowledge co-creation comes to the fore. However, the more knowledge co-creation can build on knowledge transfer and exchange, the more motivating and efficient the process is likely to become. And as noted before, co-creation is easily perceived as a community of the willing, whereby other knowledge remains invisible.

In Step 3 (Monitor), the knowledge acquired in Step 2 is contextualized. While this step may be relatively straightforward for tamer problems, even tame urban solutions acquired from elsewhere require adaptation to a specific local context and capacity development (Zahra and George 2002). If problems become more wicked, actors may not agree on problem definitions and solutions that emerge during the process. Disagreement on the relevance, validity and reliability of information, power imbalances, and conflicts may come to the fore. The more actors have conflicting values and opinions, the more political, turbulent, and complex the process becomes. However, if the discussion and debate are inclusive and deepened by continued knowledge transfer, exchange, and co-creation, then this turbulent process can lead to new learning and insights.

In Step 4 (Mobilize), knowledge is put into action by mobilizing support and resources. Power games within city networks (Laitinen, Osborne, and Stenvall 2016), organisations (Guentner and Harding 2015) and urban communities (Angehrn 2012) determine what change may happen at what pace. Unexpected challenges are likely to require further knowledge sharing (Zahra and George 2002). When problems are very wicked and actors disagree, a multitude of experiments can be initiated, reflecting a rich combination of knowledge, local practices, and values. Such experiments pilot the multiple pathways proposed in the iterative and participatory knowledge sharing process. This step requires policy makers and practitioners to move beyond incremental change and knowledge boundaries created by neocolonialism and other power constructs, experimenting with new uncomfortable approaches. If so, the implementation process itself is likely to lead to new knowledge, which can be monitored and fed back into the knowledge sharing process.

5. Conclusions and recommendations

This paper has discussed urban knowledge sharing in the context of the SDGs as wicked problems. Urban contexts represent complex social spatial environments facing a multitude of challenges related to the SDGs that oftentimes result in a variety of wickedness. Cities, as the hotspots of human existence and influence, are therefore an interesting and relevant focus for the inquiry into knowledge sharing processes. Achieving SDGs in cities is an open-ended process, whereby cities become places of experimentation and learning. Too often, however, lessons learned are not shared and important knowledge on how to achieve SDGs gets lost. This paper starts from the premise that literature applies many terms to describe knowledge sharing without clear distinctions and with inconsistent use. We use urban knowledge sharing as an overarching term, defined as an iterative process of sending, receiving, and/or collaboratively combining and (re)developing different types of information by multiple actors about urban problems and their potential solutions as experienced within complex local urban environments. This definition shows the complexities of knowledge sharing, as information must be transformed into applicable local knowledge which takes the specificities of locations, power imbalances, communities, sectors, and time period into account.

Where the adjacent field of urban policy transfer focusses on conditions on the side of the receiver, urban knowledge sharing identifies conditions of all actors engaged in the process. This illustrates the distinct nature of the phenomenon of urban knowledge sharing in relation to other, related phenomena and concepts such as policy transfer, institutional transplantation, and learning. The different fields of study would however benefit from a stronger integration, acknowledging that these processes are closely intertwined.

This review provides an overview of literature on urban knowledge sharing. Based on our review, we propose an overarching definition of urban knowledge sharing and identify three types: transfer, exchange, and co-creation. These

concepts are often not used by the authors themselves, signaling a great variety and inconsistency in the use of concepts. We have grouped literature based on the process of urban knowledge sharing and find that these processes associate with the problems addressed and main conditionalities involved.

The results of this review suggest that the more complex the urban challenge, the more suitable co-creation appears to become. As cities increasingly deal with wicked problems, scholars and practitioners assume that knowledge co-creation is most appropriate. However, the difference is less distinct than may be expected, as wicked problems can be unbundled into smaller and partially less wicked problems (Alford and Head 2017). While we acknowledge the merits of knowledge co-creation, we warn against seeing it as a panacea. There is no one-size-fits-all approach to knowledge sharing. This review shows that each type of knowledge sharing (transfer, exchange, and co-creation) has its own features and biases. Sharing knowledge on a wicked problem, such as how to develop policies for climate change, may include knowledge on tame problems which can be transferred, such as how to build a dike, knowledge which can be exchanged, such as urban policies to be used as inspiration, and knowledge which has to be co-created to fit the local context.

Based on theory, we introduce an integrated and participatory model by which practitioners can maximize knowledge sharing in a more explicit and efficient process, while visualizing power imbalances. It uses the notion of process management, which is widely used in knowledge co-creation but not in knowledge transfer and exchange, to design a process comprising four steps. It also combines insights on conditions from the three ways of knowledge sharing. In Step 1, urban actors map a wicked problem, unbundling it into small and partly less wicked problems The combination of literature on knowledge sharing with that on wicked problems (Rittel and Webber 1973; Alford and Head 2017), subsequently enables us to unbundle knowledge sharing into three parallel and interwoven processes: knowledge on tame problems can be shared in knowledge transfer, on complex problems in knowledge exchange, and on wicked problems in knowledge co-creation. In Step 3, monitoring, the three processes come together leading to debate and learning, whereby the more wicked the problem is, the more likely it leads to heated debates, power imbalances, and political turbulence. In Step 4, mobilizing, a varied amount of experiments takes place, feeding urban learning and knowledge sharing. Hereby, a variety of experiments creates multiple opportunities for learning and knowledge sharing. If these are well documented, visited, and debated, it feeds further knowledge sharing.

A warning is in place, as our model is no panacea for knowledge sharing on wicked urban problems either. The conditionalities of the three forms of knowledge sharing cannot easily be overcome and power plays are likely to lead to suboptimal processes. There may be a lack of openness to learning in organizational cultures, urban actors may be unable or unwilling to share knowledge and relationships may not be equal or based on ties of trust. Power imbalances including neocolonialism may render praxis-based indigenous knowledge invisible and limit the search for relevant knowledge. Moreover, knowledge is not neutral and differences in (technological) expertise may complicate sharing. While the proposed model cannot remedy such conditionalities, it can make them explicit and open for reflection.

The structured literature review analyzed a well-selected but limited number of articles. During the process, a range of issues came up which move beyond the context of the review and are not yet adequately addressed in literature. First, we recommend testing and developing the proposed model of knowledge sharing. Future research can develop a set of "design criteria" for the different types of knowledge sharing as well as increasing our understanding of when transfer, exchange, and co-creation are most suitable. Also, it may be interesting to see to what extent the processes of these distinct types of knowledge sharing overlap and/or under which conditions they evolve into one of the other types. Second, we recommend research to integrate theory on knowledge sharing, policy transfer, and related concepts, thereby offering a more complete overview of the processes and conditionalities. Third, we recommend research to develop a co-occurrence map of forms of knowledge sharing and SDGs, assessing if different SDGs are associated with different forms of knowledge sharing and power imbalances. This is likely to be the case, as SDGs address different problems and the actors engaged in SDGs also differ. Fourth, this broad scoping exercise can be followed up by specific studies on knowledge sharing within specific SDGs and/or disciplines. Future research can also analyze empirical case studies, assessing how knowledge sharing is applied in real-case scenarios. Finally, we recommend a time series to establish how perspectives and theories on knowledge sharing have evolved over time. This latter study may also explore if useful knowledge sharing concepts have been lost over time.

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