Scholl *et al. Urban Transformations* (2022) 4:7
https://doi.org/10.1186/s42854-022-00038-4

Urban Transformations

PERSPECTIVE Open Access

Enhancing the contribution of urban living labs to sustainability transformations: towards a meta-lab approach

Christian Scholl[1*], Joop de Kraker[1,2] and Marc Dijk[1]

*Correspondence: christian.scholl@mastrichtuniversity.nl

[1] Maastricht Sustainability Institute, Maastricht University, P.O. Box 616, Maastricht, Netherlands
[2] Department of Environmental Sciences, Open Universiteit, Heerlen, The Netherlands

Abstract

The contribution of the first generation of urban living labs (ULLs) to system-wide sustainability transformations is thus far less than expected. A possible explanation for this can be found in the focus of most ULLs on local, highly contextualized knowledge, and a missing link to system-wide transformations through diffusion and upscaling beyond the geographic boundaries of the lab. Meta-learning, i.e., learning across multiple, distributed experiments, through networked ULLs seems to offer a way forward. However, the literature on city networks shows that meta-learning cannot be effectively facilitated in horizontal networks without a learning infrastructure. To address this shortcoming and inspire a second generation of ULLs, this Perspective paper outlines a meta-lab approach actively facilitating the contribution of local living labs to wider sustainability transformations. We see a meta-lab as a transurban multi-actor network to connect and, where possible, align the learning processes across thematically related ULLs in different urban contexts through a central learning agenda. The meta-lab approach respects and supports local learning agendas and their focus on local solutions for local problems, while acknowledging and utilizing the potential of local experiments to contribute to a central learning agenda. Our paper argues that a meta-lab approach can act as a catalyst of learning in two important ways: (1) by accelerating local experimentation and learning processes by feeding them with lessons from other locations; and (2) by facilitating a more focused – local and transurban – learning process through a shared learning agenda. The meta-lab approach thus stimulates urban sustainability transformations by supporting faster, more focused and wider learning about effective innovations. We conclude this paper by outlining how common pitfalls in transurban learning can be avoided by a careful design of the meta-lab, or by meeting certain conditions when implementing this design.

Keywords: Urban living labs, Urban experimentation, Joint learning, Transurban learning, Meta-learning, Meta-lab approach, City networks, Transdisciplinary research

Science highlights

- The contribution of local learning processes in urban living labs to system-wide sustainability transformations is thus far less than expected
- A meta-lab approach can be a catalyst for local and transurban learning about wider sustainability transformations
- Pitfalls in transurban learning can be avoided by careful design of a well-structured meta-lab process

Policy and practice recommendations

- Urban living labs 2.0 should include meta-learning
- A meta-lab approach can help to move beyond narrow forms of local learning
- Key conditions need to be met when implementing a meta-lab design

Introduction

In the past decade, we have witnessed a multitude of urban living labs (ULLs) mushrooming in cities across the world[1] (Bulkeley et al. 2019; Marvin et al. 2018; Evans et al. 2016). This first generation of multi-actor platforms for co-creation, real-life experiments and joint learning in cities has received considerable scholarly attention, specifically from urban geographers (Hodson et al. 2018), urban planners (Kronsell et al. 2018), sustainability transition scholars (Von Wirth et al. 2020; Scholl et al. 2018; Bulkeley et al. 2017) and (socio-technical) innovation researchers (Dijk et al. 2018; Scholl and Kemp 2016). These studies often emphasize the potential of ULLs for innovating urban governance and planning as well as for finding innovative solutions to urban sustainability challenges. ULLs appear to fit into both the discourse of innovation under the neoliberal logic of urban competitiveness, and the promise of experimentation capable of addressing pressing urban policy agendas surrounding sustainability and climate governance (Bulkeley et al. 2014).

However, divergent views are apparent in the literature concerning the application domain of innovations generated in ULLs. Some scholars (e.g., Karvonen and Van Heur 2014) stress the ability of ULLs to create highly context-sensitive and locally-relevant knowledge, while others, including national and international funding agencies, emphasize their potential to produce scalable and transferable innovations (e.g., Schäpke et al. 2018; JPI Urban Europe 2019). This divergence coincides with a focus on the role of ULLs in transforming local governance (Scholl and De Kraker 2021a; Karvonen 2018), versus a primary interest in the contribution these labs can make to system-wide sustainability transitions (Sengers et al. 2019; Von Wirth et al. 2020). In the latter case, much attention is paid to how innovations and lessons can diffuse beyond the confines of the ULL. Although empirical studies have yielded a variety of such mechanisms (Von

[1] It is worthwhile to mention that many ULLs have been supported by specifically European policy and funds in the last 10 years, for example by the Joint Programming Initiative Urban Europe (https://jpi-urbaneurope.eu/news/urban-living-labs-by-jpi-urban-europe/).

Wirth et al. 2018; Peng et al. 2019; Loorbach et al. 2020), the contribution of urban experimentation to sustainability transformations is thus far less than expected (Evans et al. 2021; Ryghaug and Skjølsvold 2021; Grandin et al. 2018). Frantzeskaki et al. (2017) observed that in several cities impacts on adjacent or interrelated systems have been demonstrated, but that wider impacts of local experiments beyond their specific context of operation are difficult to find. Similar observations have recently been made by Eneqvist and Karvonen (2021) and Evans et al. (2021). A possible explanation for this could be found in the local focus of most ULLs, which is either at the level of the city or the neighbourhood (Bulkeley et al. 2019). In practice, ULL experimentation tends to poorly anticipate upscaling beyond the scale of the experiment (Dijk et al. 2018), and learning processes tend to remain implicit and unstructured (Evans et al. 2021). Besides, many of the local urban actors participating in ULLs do not necessarily aim at transformative change or diffusion beyond the boundaries of the lab, nor are these labs provided with the resources to do so (Scholl and De Kraker 2021b; Puerari et al. 2018; Von Wirth et al. 2018; Scholl and Kemp 2016).

Thus, there appears to be a tension between the way ULL practitioners and participants currently operate and the way experiments could contribute to tackling broader societal challenges, as argued by sustainability scholars in particular. This raises the question whether these higher ambitions can be met by following a different approach for the future generation of ULLs. Such a new approach should include improvements in the local ULL approach, but also improved connections between experiments on different places. We elaborate the second argument here in this paper: local learning processes of current ULLs and the envisioned system-wide sustainability transformations should and can be linked better through a transurban meta-learning approach. Meta-learning is understood here as learning across multiple, distributed local experiments (Wolfram et al. 2019), fostering joint learning on system-wide sustainability transformations.

Sustainability transition scholars have proposed the formation of networks to promote transfer and meta-learning across experiments and the application of lessons and innovations across geographic boundaries in order to stimulate wider sustainability transformations (Moloney and Horne 2015; Von Wirth et al. 2018; Peng et al. 2019). Some of these networks have proven to be effective in translocal diffusion of grassroots social innovations (Loorbach et al. 2020). However, our review of the broader literature on city networks below identifies several pitfalls in transurban meta-learning, specifically concerning the predominantly local focus of ULLs.

To inspire a new generation of ULLs ('ULL 2.0'), we present a perspective on how to effectively promote and coordinate transurban meta-learning processes while avoiding these pitfalls by carefully designing a new organizational structure. It concerns a so-called 'meta-lab approach', connecting local living lab experiments and facilitating meta-learning in a new way. A meta-lab can be defined as a transurban multi-actor network to connect and where possible align the learning processes across thematically related ULLs in different urban contexts through a central learning agenda. A meta-lab approach acknowledges the need for a well-framed and coordinated learning process as it has emerged in the EU's "architecture of experimentalist governance" (Sabel and Zeitlin 2008). It also goes beyond the mere comparison of differences between local solutions and forges joint learning processes. Meta-labs differ from more open and

thematically unfocused networks of living labs, such as ENoLL, in that they connect ULLs that share a thematic focus and, therefore, use some form of selection for network members. Besides, they also differ from established city networks, such as, e.g., Eurocities, ICLEI, the Climate Alliance, and 100 Resilience Cities (see Davidson et al. 2019; Frantzeskaki 2019), in that they include non-governmental actors in their membership, such as knowledge institutions, companies and citizen platforms, and provide focus for joint learning though a central learning agenda.

A meta-lab does not execute experiments itself but connects the learning processes across ULLs in different urban contexts. We argue that a meta-lab can function as a as a bridge by, on the one hand, respecting and supporting local learning agendas and their focus on local solutions for local problems, while, on the other hand, acknowledging and utilizing the potential of local experiments to contribute to a central learning agenda on system-wide sustainability transformations. ULLs are free to define what these central learning goals mean in their specific context.

Meta-labs can catalyze learning in two important ways: (1) by accelerating local experimentation and learning processes, feeding them with lessons from other locations through continued harvesting and redistribution of local lessons learned; and (2) by facilitating a more focused – local and transurban – learning process through a shared learning agenda. The meta-lab approach thus stimulates urban sustainability transformations by supporting faster, more focussed and wider learning about effective innovations.

In what follows, we first summarize common pitfalls in transurban learning as identified in the literature on city networks. These pitfalls corraborate the need for a different transurban learning approach. We then outline our perspective on the meta-lab approach providing a concrete example where this approach is implemented (SUMMALab). Finally, we sketch a number of key conditions that need to be in place in order to avoid the pitfalls of city networks and earlier ULL approaches.

Pitfalls of transurban learning in city networks

To our knowledge, attempts to facilitate explicit transurban learning processes across local ULLs and studies thereof are still scarce and limited. One recent contribution comes from Dabrowski et al. (2019) identifying barriers to knowledge transfer in the co-creation processes of networked ULLs in Amsterdam and Naples. These barriers are formulated on a fairly general level including aspects such as language, disciplinary background, geographical context, and socio-cultural and socio-economic differences. In this section, we therefore turn to pitfalls in transurban learning as identified in the literature on environmental and sustainability-oriented city networks and partnerships, national as well as international. We start with pitfalls that are directly associated with two common models to organize such networks and partnerships: the 'best practices' model and the 'leader-follower' model. In the 'best practices' model, in which cities learn from each other concerning their best practices, transurban learning can be ineffective when failures and problems are ignored and when no attention is paid to enabling factors in the specific local context of the 'best practice' (Bulkeley 2006; Nagorny-Koring 2019). In the 'leader-follower' model, follower-cities are expected to learn from more advanced 'leaders' how to adopt their innovative solutions. This model can result in shallow learning,

when followers cherry-pick the practices of leaders, without paying sufficient attention to the context, and also to an underexploitation of the learning potential of the network, when learning is one-way and leaders do not learn from followers (Shefer 2019).

Other common pitfalls in transurban learning are not *per sé* associated with the two models described above but may occur in any type of city network. The city partners might be too diverse in terms of biophysical, mode of governance or other relevant conditions such as size, so that the lessons learned by one partner are not relevant to or applicable by another partner (Wolfram et al. 2019). Mode of governance includes political aspects, such as actor roles, interests and conflicts (Castán Broto 2017). For example, lessons on shaping urban institutions for climate governance cannot be effectively transferred to cities where regional or national level support for climate policy is lacking (Frantzeskaki 2019). Transfer of lessons may also be hindered by a lack of capacity to translate and reframe lessons learned by one partner for other partners (Shefer 2019), or the importance of personal and informal exchange of knowledge for successful transfer of lessons may not be acknowledged (Lee 2019; Shefer 2019). Furthermore, learning may not be very deep or transformative due to a dominant focus on a limited set of business-as-usual solutions (Heikkinen et al. 2019). Finally, transurban learning within a network may be limited because the more advanced cities focus on one another ('pioneers-for-pioneers', Kern and Bulkeley 2009), or because many partners are inactive and participate for other purposes than learning, such as city branding or legitimizing existing approaches (Betsill and Bulkeley 2004; Hakelberg 2014).

The meta-lab approach

In order to avoid common pitfalls of transurban learning, we propose here a meta-learning approach through meta-labs as an extension of existing ULL approaches. We illustrate it with a current example where this approach is implemented: the SUMMALab Meta-lab.

SUMMALab is a network of mid-size and large cities as well as metropolitan regions, provinces, private sector partners and knowledge institutes. The SUMMALab network has agreed on a joint overarching learning agenda to connect the learning processes of local experiments with urban mobility innovations. The focus of SUMMALab's central learning agenda lies on mobility innovations that improve (1) the accessibility and (2) the liveability of the city in such a way that they are (3) socially inclusive, (4) affordable, and (5) scalable. The lessons learnt may involve governance, technological, physical, behavioural etc. aspects.

As a meta-lab, SUMMALab does not initiate and carry out experiments by itself, but supports networked learning processes across mobility experiments initiated locally in partner cities and urban regions. To this end, we have developed a framework consisting of four key elements: transurban learning coordination through three learning spaces, the process of de- and re-contextualization of experimental knowledge, a jointly formulated learning agenda, and systematic documentation of the lessons learnt.

The *transurban learning coordination* (see Fig. 1) actually consists of three interconnected learning spaces. The 'practitioners learning space' facilitates a dialogue between 'ambassadors' of the different local experiments, often working for the local city administration, based on the focus of SUMMALab's central learning agenda.

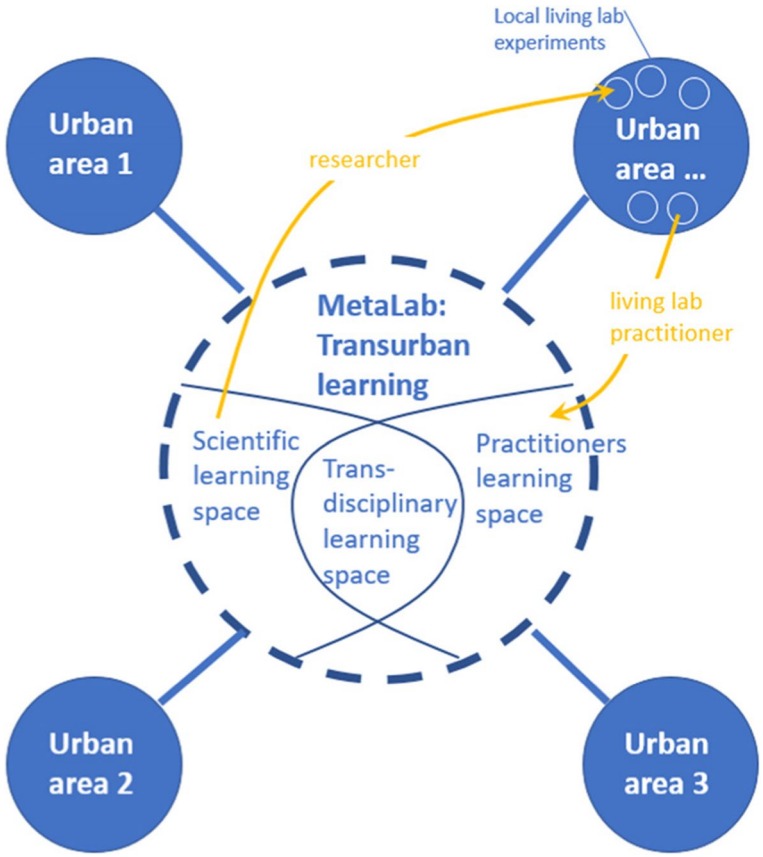

Fig. 1 The transurban learning coordination of the meta-lab approach

Next to questioning and inspiring each other, practitioners can compare approaches to and outcomes of experiments, and 'copy' successful experiments to other cities. The 'scientific learning space' analyses and integrates the results of the mobility experiments based on SUMMALab's central learning agenda. Insights from completed experiments are used to develop new and more detailed questions, in relation to the learning agenda and with respect to business models, technical aspects, impact assessment etc. The 'transdisciplinary learning space' integrates the practitioners' and researchers' learning processes by bringing them together and confronting them with each other. In this space, the joint learning agenda is discussed by researchers and practitioners. Concrete lessons from experiments are de-contextualized (i.e., jointly the lessons valid beyond the particular context of the experiments are formulated) in order to generate findings to be tested in future experiments in other places (see Table 1 for an example).

Together, these three learning spaces aim to connect and deepen the learning processes that take place locally, and are connected to them in two important ways. First, one scientific representative remains in contact with the local living lab experiment on a more continuous basis and caters for support where necessary and possible (e.g., for monitoring the impacts of a specific experiment). Second, one local living lab representative takes part in the practitioners' and transdisciplinary learning coordination.

Table 1 An example of decontextualization and recontextualisation

In SUMMALab, the process of de- and recontextualization starts when involved researchers present lessons from local experiments in the transdisciplinary learning space. For instance, a researcher presented such lessons in response to one of the questions of the overarching transurban learning agenda: *How could you, as a municipality, prepare for the upscaling phase of an experiment*? The lessons were based on an analysis of a running experiment on neighbourhood mobility hubs in Amsterdam. The analysis indicated that to anticipate the upscaling of neighbourhood hubs, the municipality could best: - Choose a city-wide scope from the start, and develop an approach that can be repeated in other neighborhoods. - Go for a bottom-up approach, and customize for the specific context of the neighborhood together with the residents. - Involve from the beginning not only external but also internal stakeholders, i.e., the (later) relevant municipal departments. After the lessons from this local experiment were presented, the following question was posed to the practitioners of other cities: 'to what extent are these lessons also useful / applicable /relevant for your city?' This was to start the de- and recontextualisation of the lesson. Practitioners mentioned the following relevant aspects of the context of the experiment in Amsterdam: - It was an externally co-funded project, and part of a larger international project, with notable ambitions, reflected in a project proposal that already promised the development of 10-15 neighborhood hubs in Amsterdam. - It was implemented in existing neighborhoods, not in new neighborhood developments. The practitioners also mentioned that findings were not so applicable for smaller cities, with smaller municipal organizations and less departmental barriers. Neither would it be relevant for newly built neighborhoods, nor for hubs near larger public transport hubs. Subsequently, a Mentimeter-poll was distributed in which participants were asked to choose one of the following answers concerning how useful / applicable /relevant these lessons were for their city: (a) No, (b) Yes, but very different context (needs major translation), (c) Yes, but slightly different context (needs minor translation), (d) Yes, I can apply it 1-to-1. Most participant choose (c): need for minor translation. Participants from Rotterdam and The Hague explained that for their existing neighborhoods these lessons were applicable as well. In Rotterdam the need to involve municipal departments was recognised as being essential, because otherwise this likely leads to problems and delays later in the process. The need for minor translations stems from particular local nuances in policy priorities, e.g., the importance of social inclusion in Rotterdam. In The Hague, a minor translation is needed because the first hubs are implemented as part of spatial redevelopment of neighborhoods because of new sewage systems.

They have a bridging function by contributing local experiences and lessons to the meta-lab, as well as feeding transurban insights back to their local living lab.

A key moment for bringing the three learning spaces together are the half-yearly (if possible physical) meetings in one of the partner cities with ample space for interaction and co-design including a site visit to one of the involved experiments. The focus in the learning spaces is on three main activities: joint learning from completed and ongoing experiments, aligning learning agendas for new experiments with the central SUMMALab learning agenda, and identifying the support necessary for the new experiments.

These learning activities (see Fig. 2) are fed by what we call the processes of *de-contextualisation and re-contextualisation of experimental knowledge*. De-contextualization refers here to what needs to happen with the lessons and insights that are taken to the learning spaces from the local living lab experiments. By comparing them to other experiments in other places and 'stripping' them from their embeddedness in the local context, these lessons can become more generic, recognisable and useful for future experiments in other urban contexts. By formulating and storing these decontextualized lessons together in half-yearly learning spaces, researchers and practitioners support the design of new local experiments as it can both draw on local lessons from previous experiments and decontextualized lessons provided by the local ambassador participating in the meta-lab. Before and through the application in a new context, de-contextualized lessons are re-contextualized again. Their meaning needs to be made specific for the

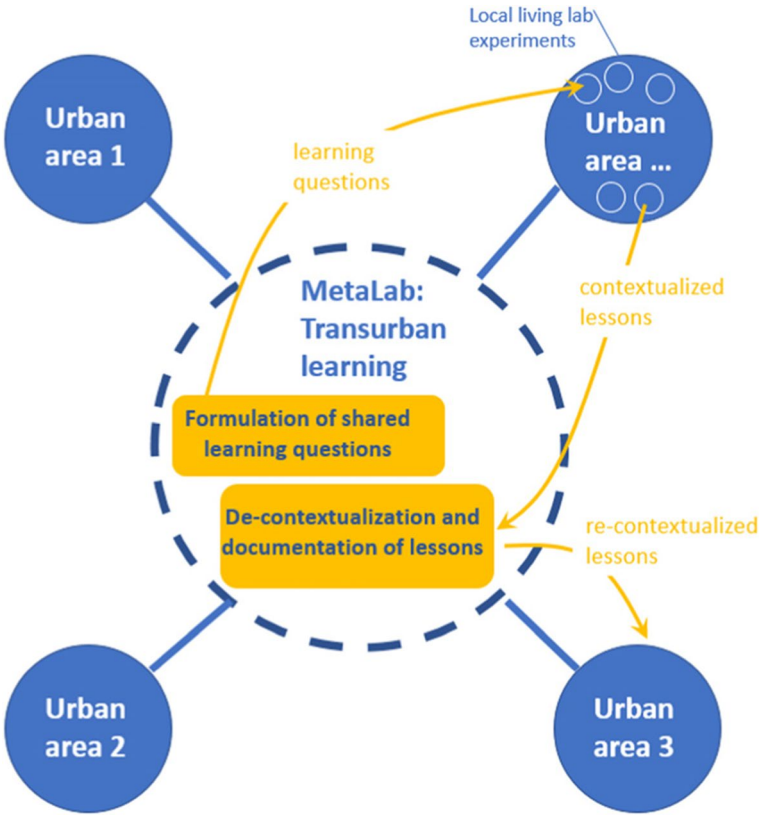

Fig. 2 The learning activities part of the meta-lab approach

local context, the type of experiment that is designed and the actors who are involved in that process. Nevertheless this process of re-contextualizing de-contextualized knowledge offers opportunities for acceleration of experimentation and upscaling of solutions found. Table 1 provides a concrete example of this process.

The processes of de- and re-contextualization show how important it is to align local and transurban learning processes. The key instrument to facilitate this alignment process is the so-called *learning agenda*. A learning agenda lists a set of substantive, operational and strategic questions on which the learning process should focus. This learning agenda should be jointly established and agreed upon in order to ensure the commitment of all involved actors. Reflecting the assumption that joint learning is not likely to occur without focus, the learning agenda helps to focus on actually relevant lessons. As mentioned earlier, in SUMMALab, there is a jointly determined, overarching transurban learning agenda. On the one hand, this learning agenda helps to filter the lessons coming from the local living lab experiments. On the other hand, it also steers local learning processes by aligning the local learning agendas and the transurban one. This is achieved in the learning spaces where the local learning agendas of planned experiments are jointly discussed.

The final key element is the *documentation of lessons*, crucial for the meta-lab's learning cycle (see Fig. 3). Together with their respective learning agendas, local lessons of living lab experiments need to be documented in order to be available to other practitioners and specifically the learning spaces. The decontextualized lessons, drawn in the

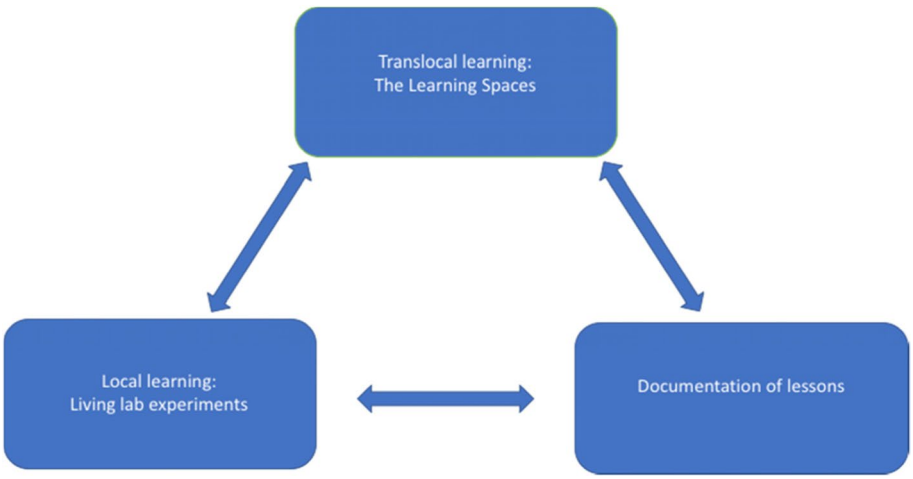

Fig. 3 The learning cycle enabled by the meta-lab approach

half-yearly learning spaces by discussing and comparing completed experiments, also need to be documented alongside with the evolving meta-lab learning agenda.

Key conditions for successful application

To apply the proposed meta-lab approach successfully, the pitfalls in transurban learning listed above should be avoided. Through a careful design of the meta-lab, several of these pitfalls can effectively be addressed, which we will illustrate below with the example of SUMMALab. Other pitfalls require caution in the way this design is implemented in practice. A summary is presented in Table 2.

A crucial element in the design of SUMMALab is the support framework it offers for meta-learning, i.e., learning across many local experiments. De- and re-contextualisation of lessons is achieved by joint reflection of scientific experts and local practitioners on the results of completed experiments and the set-up of new experiments. As experiments are followed from beginning till end, learning can be comprehensive, including failures as well as successes, and with ample attention for local conditions and context factors. A transformative focus is ensured by including sustainability and social inclusion as goals in the central learning agenda, while at the same time allowing for a diversity in interests by respecting local learning agendas and local interpretations. This also includes respecting other interests in addition to learning, such as local agenda-setting and mobilisation of local actors. The importance of socialization and personal exchange in transurban learning is acknowledged by organizing regular face-to-face meeting that include drinks and site visits to local experiments. Finally, the structure of the learning network is flat, with similar roles and contributions expected from all city partners in the network, to promote mutual and joint learning. Local experimentation capacities and competences are brought to an equal level by offering in-person advice and a range of support tools.

The implementation of such a meta-lab design should meet a range of conditions to fully exploit its potential for transurban learning between local living labs. First, the city partners should not be too different in challenges, priorities and governance systems.

Table 2 Common pitfalls of transurban learning in city networks and how these are addressed by design elements and implementation conditions of the meta-lab approach

Common pitfalls of transurban learning	Solutions offered by meta-lab approach
Focus on successes, while failures and problems are ignored	Experiments are followed from beginning till end, including failures as well as successes Continuity in participation of local representatives to facilitate the follow-up of local experiments through time
Lack of attention for the specific local context of 'best practices', including enabling factors	Ample attention for local conditions and context factors Expert facilitation of de- and re-contextualisation of lessons
Learning in one-way direction ('leaders' do not learn from 'followers')	Horizontal network structure, with similar roles and contributions expected from all partners Capacities of partners are brought to an equal level by offering advice and support tools
The partnership is too diverse, so that the lessons learned by one partner are not relevant for other partners	Membership is restricted to cities with comparable conditions
Lack of capacity to translate and reframe lessons learned by one partner for other partners	De- and re-contextualisation of lessons by joint reflection of scientific experts and local practitioners on completed and planned experiments Expert facilitation of de- and re-contextualisation
The importance of personal and informal exchange of knowledge is not acknowledged	Regular face-to-face meetings that include socializing and site visits to local experiments Continuity in participation of local representatives
Dominant focus on a limited set of business-as-usual solutions	Transformative goals are included in the central learning agenda
More advanced cities focus on each other ('pioneers-for-pioneers')	Horizontal structure of the learning network; local capacities are brought to an equal level by offering advice and support tools Fees are not too high to prevent an elite-network of wealthier cities
Partners are inactive and participate for other purposes than learning	Other interests aside from learning are respected, without becoming dominant Appointment of dedicated 'meta-lab officials' to safeguard the primary focus on transurban learning Fees are not too low to keep out partners without genuine interest in learning

In the example of SUMMALab for example, it appears best to restrict membership of the network to the Netherlands, as the biophysical and sociopolitical conditions are sufficiently similar to generate applicable lessons. Second, it is important to strive for continuity in participation of partner representatives at personal level. This is both to support learning through personal exchange, and because learning is based on following local experiments through time. Third, there is a need for dedicated 'meta-lab officials' whose role is to safeguard the meta-lab's primary focus on transurban learning. As mentioned, in SUMMALab other interests are respected as motivations for membership and experimentation, but these interests should not become dominant. Also, the membership fee for SUMMALab is substantial, which is expected to filter out partners that are not genuinely interested in transurban learning. On the other hand, care must be taken that these fees do not result in an elite-network of large, advanced cities. Finally, the process of de- and re-contextualisation of lessons is crucial in the proposed meta-lab approach, but also difficult and prone to unhelpful simplication. Therefore, expert facilitation of this process is essential for effective transurban learning.

Conclusion

The contribution of urban experimentation to sustainability transformations is thus far rather limited. We have argued that possible explanations for this could be found in the local focus of most ULLs and a lacking transurban learning process beyond the geographic boundaries of the lab. Whereas current networked learning approaches may look appealing at first sight, the literature on city networks indicates many pitfalls.

To inspire a new generation of ULLs avoiding the pitfalls of both city networks and localized ULL approaches, we proposed the meta-lab approach as a bridge by, on the one hand, respecting and supporting local learning processes and their focus on local solutions for local problems, while, on the other hand, acknowledging and utilizing the potential of local experiments to contribute to a central learning agenda on system-wide sustainability transformations. As transurban multi-actor networks connecting and aligning learning processes across thematically related ULLs in different urban contexts through a central learning agenda, meta-labs go beyond previous attempts of networking cities and facilitating transurban knowledge transfer.

We have argued that meta-labs can catalyze meta-learning in two important ways: (1) by accelerating local experimentation and learning processes, feeding them with lessons from other locations; and (2) by facilitating a more focused – local and transurban – learning process through a shared learning agenda. The meta-lab approach thus stimulates urban sustainability transformations by supporting faster, more focussed and wider learning about effective innovations.

We presented SUMMALab as a concrete example of the meta-lab approach, and confronted this initiative with common pitfalls in transurban learning. It appears that a part of these pitfalls can be avoided by careful design of the meta-lab, whereas other pitfalls must be addressed by meeting certain conditions when implementing this design. These conclusions are promising, but as SUMMALab is currently yet in its third year of operation, the real test of the meta-lab approach is still to come.

Acknowledgements
We thank Janneke ten Kate from Platform 31 for the final design of the figures presented in this paper.

Authors' contributions
All authors have contributed to the conceptualization, writing, revision and editing of the manuscript, but to varying degrees reflected in the author order. All authors have read and agreed to the published version of the manuscript.

Authors' information
Christian Scholl (PhD) is Assistant Professor at Maastricht University. His research focuses on urban sustainability, participatory and collaborative forms of governance, and social learning. He has coordinated several transdisciplinary research projects on Urban Living Labs delivering interactive and reflexive support tools for practitioners and their experimental learning processes. These tools have been widely disseminated and well-received by a wide range of governance actors. See also: https://www.maastrichtuniversity.nl/christian-scholl.
Joop de Kraker (PhD) is Professor of Sustainability Assessment at Maastricht University and Associate professor of Environmental Science at the Dutch Open University. His current research focuses on sustainable urban development, with particular attention for urban ecosystem services, and multi-actor experimentation and learning. He is/was also involved in five research projects on Urban Living Labs. His original background is in ecological systems analysis, modelling, and decision support. See also: https://www.maastrichtuniversity.nl/j.dekraker.
Marc Dijk (PhD) is assistant professor and research coordinator at Maastricht Sustainability Institute at Maastricht University. His main research interests are innovation and innovation policy, sustainability assessment, and societal transformations. He is also Honourable Research Associate at Oxford University (Transport Studies Unit). Currently, he works on action-research projects in Living Labs focused on transdisciplinary learning, upscaling, and social exclusion (SummaLab and EmbedterLabs, NWO), and on circular business model innovation (Circular-X, ERC).

Funding
The research for this papers is partly based on the Smart Urban Mobility MetA Lab (SUMMAlab) project, funded by the Dutch research council NWO (Nederlandse Organisatie voor Wetenschappelijk Onderzoek), project number: 439.18.460 B.

Availability of data and materials
Data cannot be shared yet, as the research project is still ongoing.

Declarations

Competing interests
None.

Received: 8 September 2020 Accepted: 9 April 2022
Published: 21 May 2022

References

Betsill MM, Bulkeley H. Transnational networks and global environmental governance: the cities for climate protection program. Int Stud Q. 2004;48(2):47–493.
Bulkeley H. Urban sustainability: learning from best practice? Environ Plan A Econ Space. 2006;38(6):1029–44.
Bulkeley HA, Edwards GAS, Fuller S. Contesting climate justice in the city: examining politics and practice in urban climate change experiments. Glob Environ Chang. 2014;25:31–40.
Bulkeley H, Coenen L, Frantzeskaki N, Hartmann C, Kronsell A, Mai L, et al. Urban living labs: governing urban sustainability transitions. Curr Opin Environ Sustain. 2017;22:13–7.
Bulkeley H, Marvin S, Voytenko Palgan Y, McCormick K, Breitfuss-Loidl M, Mai L, et al. Urban living laboratories: conducting the experimental city? Eur Urban Region Stud. 2019;26(4):317–35.
Castán Broto V. Urban governance and the politics of climate change. World Dev. 2017;93:1–15.
Dabrowski M, Varjú V, Amenta L. Transferring circular economy solutions across differentiated territories: understanding and overcoming the barriers for knowledge transfer. Urban Plan. 2019;4(3):52–62.
Davidson K, Coenen L, Gleeson B. A decade of C40: research insights and agendas for City networks. Global Policy. 2019;10(4):697–708.
Dijk M, De Kraker J, Hommels A. Anticipating constraints on upscaling from Urban innovation experiments. Sustainability. 2018;10(8):2796.
Eneqvist E, Karvonen A. Experimental governance and urban planning futures: five strategic functions for municipalities in local innovation. Urban Plan. 2021;6(1):183–94.
Evans J, Karvonen A, Raven R, editors. The Experimental City. Oxon & New York: Routledge; 2016.
Evans J, Vácha T, Kok H, Watson K. How cities learn: from experimentation to transformation. Urban Plan. 2021;6(1):171–82. https://doi.org/10.17645/up.v6i1.3545.
Frantzeskaki N. How City-networks are shaping and failing innovations in Urban institutions for sustainability and resilience. Global Policy. 2019;10(4):712–4.
Frantzeskaki N, Broto VC, Coenen L, Loorbach D. Urban sustainability transitions: the dynamics and opportunities of sustainability transitions in cities. In: Frantzeskaki N, Broto VC, Coenen L, Loorbach D, editors. Urban sustainability transitions: Taylor & Francis; 2017.
Grandin J, Haarstad H, Kjærås K, Bouzarovski S. The politics of rapid urban transformation. Curr Opin Environ Sustain. 2018;31:16–22.
Hakelberg L. Governance by diffusion: transnational municipal networks and the spread of local climate strategies in Europe. Global Environ Politics. 2014;14(1):107–29.
Heikkinen M, Ylä-Anttila T, Juhola S. Incremental, reformistic or transformational: what kind of change do C40 cities advocate to deal with climate change? J Environ Policy Plan. 2019;21(1):90–103.
Hodson M, Evans J, Schliwa G. Conditioning experimentation: the struggle for place-based discretion in shaping urban infrastructures. Environ Plan C Politics Space. 2018;36(8):37–51.
JPI Urban Europe. Strategic research and innovation agenda 2.0. 2019. Retrieved from: https://www.jpi-urbaneurope.eu/app/uploads/2019/02/SRIA2.0.pdf.
Karvonen A. The city of permanent experiments? In: Turnheim B, Kivimaa P, Berkhout F, editors. Innovating climate governance: moving beyond experiments. Cambridge: Cambridge University Press; 2018. p. 201–15.
Karvonen A, Van Heur B. Urban laboratories: experiments in reworking cities. Int J Urban Reg Res. 2014;38(2):379–92.
Kern K, Bulkeley H. Cities, europeanization and multi-level governance: governing climate change through transnational municipal networks. J Common Mark Stud. 2009;47(2):309–32.
Kronsell, Mukhtar-Landgren A, Mukhtar-Landgren D. Experimental governance: the role of municipalities in urban living labs. Eur Plan Stud. 2018;26(5):988–1007.
Lee T. Network comparison of socialization, learning and collaboration in the C40 cities climate group. J Environ Policy Plan. 2019;21(1):104–15.
Loorbach D, Wittmayer J, Avelino F, Von Wirth T, Frantzeskaki N. Transformative innovation and translocal diffusion. Environ Innov Soc Trans. 2020;35:251–60.
Marvin S, Bulkeley H, Mai L, McComerick K, Voytenko Palgan Y, editors. Urban Living Labs. Experimenting with City Futures. Oxon & New York: Routledge; 2018.
Moloney S, Horne R. Low carbon urban transitioning: from local experimentation to urban transformation? Sustainability. 2015;7(3):2437–53.
Nagorny-Koring NC. Leading the way with examples and ideas? Governing climate change in German municipalities through best practices. J Environ Policy Plan. 2019;21(1):46–60.
Peng Y, Wei Y, Bai X. Scaling urban sustainability experiments: contextualization as an innovation. J Clean Prod. 2019;227:302–12.

Puerari E, De Koning J, Von Wirth T, Karré P, Mulder I, Loorbach D. Co-creation dynamics in Urban living labs. Sustainability. 2018;10:1893.
Ryghaug M, Skjølsvold TM. Pilot society and the energy transition: the co-shaping of innovation, participation and politics: Springer Nature; 2021.
Sabel CF, Zeitlin J. Learning from difference: the new architecture of experimentalist governance in the EU. Eur Law J. 2008;14(3):271–327.
Schäpke N, Stelzer F, Caniglia G, Bergmann M, Wanner M, Singer-Brodowski M, et al. Jointly experimenting for transformation? Shaping real-world laboratories by comparing them. GAIA - Ecol Perspect Sci Soc. 2018;27:85–96.
Scholl C, De Kraker J. Urban planning by experiment: practices, outcomes, and impacts. Urban Plan. 2021a;6(1):156–60.
Scholl C, De Kraker J. The practice of urban experimentation in Dutch City labs. Urban Plan. 2021b;6(1):161–70.
Scholl C, Kemp R. City labs as vehicles for innovation in urban planning processes. Urban Plan. 2016;1(4):89–102.
Scholl C, De Kraker J, Hoeflehner T, Eriksen MA, Wlasak P, Drage T. Transitioning Urban experiments. Reflections on Doing Action Research with Urban Labs. GAIA. 2018;27(S1):78–84.
Sengers F, Wieczorek AJ, Raven R. Experimenting for sustainability transitions: a systematic literature review. Technol Forecast Soc Chang. 2019;145:153–64.
Shefer I. Policy transfer in city-to-city cooperation: implications for urban climate governance learning. J Environ Policy Plann. 2019;21(1):61–75.
Von Wirth T, Fuenfschilling L, Frantzeskaki N, Coenen L. Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. Eur Plan Stud. 2018;27(2):229–57.
Von Wirth T, Frantzeskaki N, Loorbach D. Urban living labs as inter-boundary spaces for sustainability transitions? In: Handbook on planning and complexity: Edward Elgar Publishing; 2020.
Wolfram M, Van der Heijden J, Juhola S, Patterson J. Learning in urban climate governance: concepts, key issues and challenges. J Environ Policy Plan. 2019;21(1):1–15.

Publisher's Note