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“From Abstractness to Concreteness – experiential knowledge and the role of prototypes in design research”

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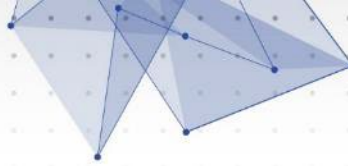
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Prototyping for Policy Making: Collaboratively Synthesizing Interdisciplinary Knowledge for Climate Neutrality

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Abstract

Cities around the world are confronted with the unprecedented grand challenge of reaching carbon neutrality. Policymakers need support in translating the abstractness and complexity of the net zero goal into concrete actions. A prototype has been developed to support urban policy makers in understanding, selecting and tracking the implementation of social innovation approaches as levers to reach climate neutrality. The creation of the prototype develops new knowledge by synthesizing contributions from academic literature, case studies, and experts' opinion, based on cities' needs, and is embodied into an interactive tool of social innovation actionable pathways for climate neutrality. Testing the prototype with policymakers provided insight into cities' envisioned interaction with the tool, leading to the redesign of the prototype into a more engaging interactive tool, and an integrated approach with more technical solutions. The developed prototype categories were based on a synthesis of scientific articles, and bottom-up information from 36 practice-based cases of social innovation for climate neutrality. The design and development of the prototype of the social innovation actionable pathways tool has been informed by the analysis of cities' needs conducted within the NetZeroCities project, which supports 112 European cities in reaching climate neutrality by 2030. A team of experts aggregated the large amount of information derived from literature, cases and users' needs into a pathway and visualized it in an interactive diagram, with the aim to support strategic decision making at urban level, by lowering information overload, providing visual guidance. The testing phase results provided further knowledge: a more engaging visual tool was perceived by policymakers as valuable to start considering social innovation actions in their cities' policies, due to the scarcity of policy makers' time and understanding of social innovation's contribution to climate neutrality. Interaction design could support policymakers in better strategizing.

Social Innovation; NetZero; Knowledge Visualization; Interactive Design; City

Designing services to support policymaking and the development of urban action plans has the potential to provide a relevant impact on shaping how the future could be. Politicians and policymakers are confronted with the complexity of grand challenges, in particular the urgent need to reduce carbon emissions. The EU-funded project *NetZeroCities* aims at supporting 112 European cities to reach climate neutrality by 2030. Going beyond the assumption that technological solutions alone can lead to net zero, the project focuses on important levers of change, such as governance and social innovation. It well established in academic literature

that innovation in social practices is an important and necessary component of reaching carbon neutrality (Chilvers & Longhurst, 2016; Angelidou & Psaltoglou, 2017; Hoppe & De Vries, 2019; Ostfeld & Reiner, 2020; Andion et al., 2021; Creutzig, Niamir, Bai et al., 2022). Furthermore, sustainable development needs collective action and systemic innovation (Diepenmaat, Kemp & Velter, 2020). Beyond a restricted focus on acceptance and behavioral change, social innovation can activate citizens to contribute to climate neutrality (Schönwälder, 2021), in particular in reducing Scope 3 emissions. In a systematic literature review on the contribution of social innovation to climate neutrality (Bresciani, Rizzo & Deserti, 2022), 267 scientific articles were identified that provide evidence of the contribution that innovative social practices have to lower carbon emissions as well as contributing to wellbeing (Engelbrecht, 2018). Yet, this rich body of academic knowledge does not seem to be systematically deployed by policymakers.

Social innovation initiatives led by citizens that aim to lower emissions are proliferating, from sharing assets to creating energy communities, and from developing peer-to-peer education on reducing the energy consumption at home, to developing certifications of climate friendly business approaches. An extensive review of such cases has been developed within the NetZeroCities project (Bresciani, Rizzo & Deserti, 2022; Mureddu & Bresciani, 2023), with the identification and description of 36 case studies at different scales, including bottom-up citizens-led initiatives as well as top-down political choices, and policies for supporting the emergence and scaling of social innovations aimed at climate neutrality. However, an investigation of social innovation action plans at global level returned only a handful of cities and regions (Taiwan, Montreal, British Columbia), which possess a social innovation action plan. Furthermore, these plans are not specifically focused on climate neutrality goals.

Can design support policymakers and politicians in understanding available knowledge from academic literature and existing cases? And could the act of prototyping together support the development of social innovation acts that can serve as a lever for reducing carbon emissions?

In order to address this pragmatic need, a prototype of an online service was developed for cities, which aims to provide a user-friendly and actionable aggregation of extant knowledge which could support policymakers in developing informed plans urban level. In doing so, facilitating the creation of favorable ecosystems that could support the emergence and scaling of social innovation initiatives (Terstriep, Rehfeld & Kleverbeck, 2020). Prototyping the service according to the principles of clear communication (Bischof & Eppler, 2011), and the known benefits of knowledge visualization (Bertschi et al., 2013) contributes to theory development by investigating how complex, vague and scattered knowledge can be aggregated in a visual and cognitively efficient format, making it pragmatically useful for cities.

The results of the prototype testing with policymakers not only advances the development of the interactive tool, but also theoretical knowledge, as implicit assumptions are exposed through the experiential interaction with the prototype, thereby generating new knowledge on unexpressed users' needs (Valentine, 2013). For example, the potential benefits of renaming "social innovation for climate neutrality" into "people-based solutions", and the creation of visually attractive interfaces for policymakers.

Furthermore, the act of collaborative prototyping, a user-centered service based on interdisciplinary knowledge (Bogers, & Horst, 2014), enabled the exploration of the interconnections between the three fields of social innovation, policy making and sustainability (Groth et al., 2020).

Prototyping as Knowledge Generation

Based on a series of co-design workshops which took place within the NetZeroCities project, users expressed the need for a service that could provide solid guidance to policymakers and stakeholders in understanding the potential actions that a city could take to support social innovation initiatives. Specifically, users need guidance in developing and scaling of social innovation initiatives aimed at climate neutrality, based on their current level of readiness or contextual factors. Contextually, cities (as well as the government and funding bodies including the European Union) also face the need to measure the effectiveness of the actions and policies they develop. Therefore, the service should include both a planning and an assessment component.

In order to develop such a service, labelled *social innovation actionable pathways*, a sprint was organized with a multidisciplinary group of social innovation experts from different organizations to develop and test a prototype. The group of experts was composed by the first three authors (all of whom have a background in design and social innovation), an expert of democracy and social innovation from Southern Europe, an expert of policies and social innovation from Northern-Europe and a smart cities expert from a Northern European technological university. The methodology adopted for the development of the prototype of the service was the following: firstly, users' needs were analyzed (based on two deliverables of the NetZeroCities project) in terms of cities' expectations for social innovation and action plans. Secondly, insights from a literature review on the contribution of social innovation to climate neutrality (Bresciani, Rizzo & Deserti, 2022), EU-funded projects on the topic, the theory of change developed in the NetZeroCities project (Chaudary, Hawkins & Alvial Palavicino, 2022) as well as data from the 36 cases developed within the project (Romero et al., 2023), were aggregated in a shared online platform. The experts met in three workshops to design the user-centered service, during which the abovementioned insights were synthesized in meaningful categories.

This process of knowledge aggregation went through multiple steps and visual formats (Fig 1-2), comparing multiple criteria and frameworks (including the guide to scaling social innovation developed by the Schwab Foundation and the World Economic Forum (2013), Social Entrepreneurship Ecosystem Assessment developed by the European Commission and OECD¹, and the categories determined within the NetZeroCities project). All experts were involved in providing input and co-creating the categories during the process.

¹ <https://betterentrepreneurship.eu/en/node/802>



Figure 1: An example of how the knowledge was aggregated and categorized.

Starting from the cities' policymakers' needs, a prototype was developed, deploying the principles of visual and clear communication, in that it should (1) be concise, (2) have a logical structure, (3) have explicit content, (4) be low in ambiguity, (5) and ready to use (Bischof & Eppler, 2011). In addition, visualizing knowledge provides several advantages (Bertschi et al., 2011): it lowers information overload (Eppler, 2006), thus improving the quality of strategizing (Eppler & Platts, 2009), and increases understanding and recall (Bresciani et al., 2011). Specifically for the prototyping of the service, visualizing the synthesis and aggregation of knowledge provides not only a provides a cognitively efficient interface, but also a new theoretical framework of social innovation actions at urban level which can support climate neutrality. Secondly, the prototype links actions to measurement of outputs and outcomes of each proposed action, therefore linking social innovation actions to relevant indicators derived from the literature.

2. Creating favourable SI ecosystem	Dedicated funds (how to get them)	Available fundings and cross sector partnerships, sponsoring, philanthropy,	Amount of funding dedicated to the city's Social Innovation initiatives (training, seeding, co-creating, etc.) # of types of funding mechanism for the city's Social Innovation initiatives, total of getting credit, total public social expenditure			Platform resources on finance	The Economist (2015, p7)	
	Infrastructuring: physical and virtual SI intermediaries	hubs, incubators platforms to share skills and needs (Case Nifty neighborhood)	# of co-creation environments devoted to SI Presence of a SI hub or lab or transfer center Presence of SI networking platforms or spaces			Social innovation hub	<p>WEF Engage market stakeholders. Foster network, structures that allow communication and coordinated action between investors, entrepreneurs, civil society and policy-makers.</p> <p>Morais da Silva et al. (2015, p154): involvement of members of local community</p> <p>The Economist (2013, p7): civil society engagement, culture of volunteerism</p>	
	Co design of policies and new governance arrangements	Reflexivity and testing of new policies	# of co-created policies boosting social innovation # of social innovations developed from policy initiatives co-created/# of social innovations developed from policy initiatives non co-created		3		<p>WEF Review and Refine Policy (case: Social Benefit Bonds in Australia)</p>	
	Media/discourses to place SI on the agenda	Active Media Relations on SI Case: Senegal Visible results: communication and social media platform, events, awards, artistic interventions for change narrative	Presence of an active media relations strategy for SI Number of initiatives aimed at generating positive PR on SI Number of media clips on SI (newspapers, tv, magazines, radios)					
	Willingness to invest in SI							

Figure 2: An extract of the collaborative board utilized for the classification of cases, scientific literature and policy articles according to categories.

The first version of the prototype (Fig. 3) is visualized as a timeline composed of 14 categories along three subsequent steps of a pathway: *prepare, act and accelerate* (based on the categories of the City Climate Planner Program developed by ICLEI²). Clicking on each category, a box with additional information opens, outlining specific actions, indicators (which are related to SDG goals), and academic references on which the claim is based on. This first rough prototype was presented to a larger group of experts on social innovation, carbon transitions and policy making, within the NetZeroCities consortium. Their feedback was integrated into a more visually appealing and visually coherent prototype (in which all categories had the same size), which resulted into the development of two alternative prototypes to be presented to users.

More specifically, two customer journeys were envisioned (according to traditional categories, which include user actions, user needs, user emotions and touchpoints), leading to the same core visualization of the service. In the first option, the user (which is the city's transition team, as well as policy makers, politicians, etc.) would first answer a questionnaire to gather information on the city's current status, and based on the questionnaire results the online service would automatically highlight suitable next actions. In addition, the system would provide a visual benchmark in the format of yellow stars (1, 2 or 3 stars) to show the performances of a city for each category (see Fig. 4). In the second option, users would directly access the overall interactive map (Fig. 4), and could click on each category and optionally answer the indicators' questions.

² <https://cityclimateplanner.org/resources>

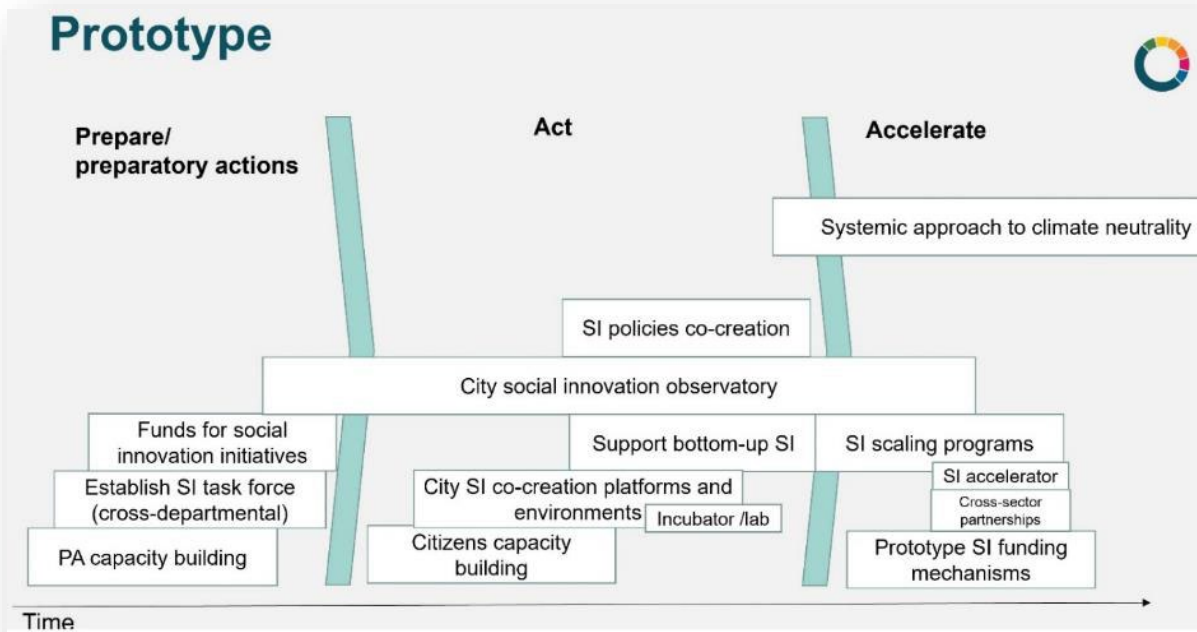


Figure 3: First version of the prototype with categories of social innovation actions for climate neutrality.

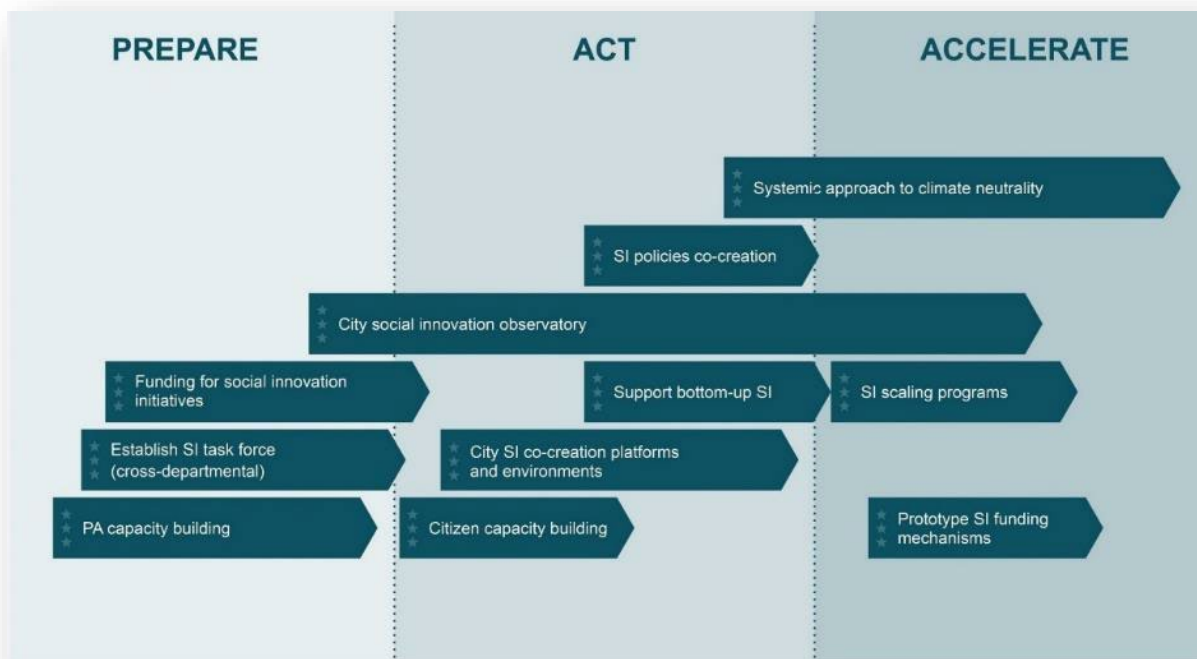


Figure 4: Second version of the prototype: after answering a questionnaire, users can see an overview of the categories and their own scores (visualized as stars for each category).



Figure 5: Second version of the prototype: content can be freely explored and optionally integrated by answering questions related to indicators for tracking progresses.

Although the interactive map remains the same, the user journey is different: in the first version, users have to answer a questionnaire to be able to access the map and have customized suggestions of actions to take based on their social innovation readiness.

Insights from Testing and Redesign

To test the prototypes (Fig. 4 and 5), a panel with cities' policy makers was organized online. The participants were three members from the transition teams of their respective cities, which all were small/medium-sized Southern European cities.

Although the participants were willing to use the tool in an explorative way if it did not take too much effort to learn how to use it, they indicated that the connection between social issues and climate neutrality was not evident, and not a priority for their cities. Furthermore, they did not seem to have an accurate understanding of what was meant with 'social innovation'. In addition, they voiced their concern regarding the difficulty in getting the buy-in of the city administration in general on climate neutrality or sustainability, thus needing to link actions to politically relevant and easily communicable topics, such as citizens wellbeing. However, the participants were interested to know how their city is performing compared to other cities in their respective countries and in Europe, and which other cities have already implemented which actions. Finally, a relevant point raised was regarding the language in which the tool would be delivered, which would have to be the local language, as not all politicians and policymakers are comfortable with using English.

The users' feedback was relevant for theory development: contextual factors, such as political commitment and language skills, could prevent the use of the service. In practical terms, the prototype could be improved by including a mobilization phase to convey the relevance of social innovation for the reduction of carbon emissions, perhaps by renaming "Social Innovation for Climate Neutrality" into "People-based Solutions" to align terminology with Nature-based Solutions (Cohen et al., 2016; Faivre et al., 2017). This assumption would need testing before implementation.

From the two options tested, it seems that starting the interaction with a questionnaire would create a barrier, and thus prevent users from using the service, since they do not necessarily understand its value upfront. Therefore, providing a more playful visual interactive infographic without overwhelming potential users seems a suitable user-centered option, as this allows cities to explore the categories in an interactive format, answering the associated questions and tracking their progresses over time. This coincides with the *information seeking mantra*, which is the notion that knowledge is navigated and explored by providing overview first, then zooming into specific topics and further details on demand, (Shneiderman, 2003).

Finally, emphasizing the politically relevant benefits would be useful for engaging politicians in utilizing the tool to develop the cities' transition/action plans to climate neutrality, complementing technological solutions. To address to this challenge, the service could emphasize the co-benefits of both social innovation and decarbonization in terms of citizens wellbeing and improved quality of life. Cases focused on the communication of the co-benefits should therefore be added as well as indicators related to wellbeing. The data resulting from the indicators should then be visualized in a dashboard in which a city's scores can be compared with the country's average or other European cities. Based on the insights from testing, the customer journey and the prototype of the online service were revised. An interactive prototype was created using Kumu, an online platform specialized in mapping relationships (Fig. 6), enabling the content to be interactively explored to test information seeking behavior and usability. Clicking on one of the green fields loads the related content on the left-hand side of the screen, which contains the description of potential actions cities could take, a list of case studies of cities which already implemented this particular action as well as other relevant resources, suggested indicators and academic references.

The content of the third prototype (Fig. 6) was refined together with social innovation experts from within the NetZeroCities consortium. Since some categories were unbalanced, they were reduced. The content for each category was further linked to resources available on the NetZeroCities platform. Iteratively, new content was added to provide cases and references related to the needs identified in the earlier city panel testing phase (i.e. cases and indicators on co-benefits and communication). In this way, the interactive service helped users to transform abstract concepts into concrete actions.

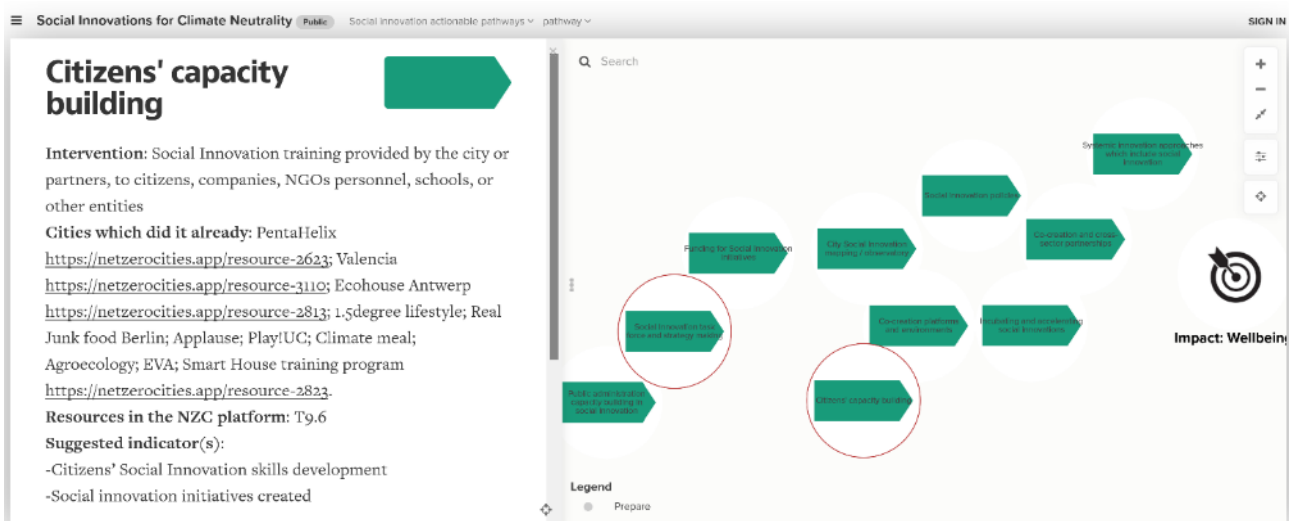


Figure 6: Third version of the prototype: interactive prototype with content on demand.

Implications

Pragmatic Implications

Although several pathways to climate neutrality have been proposed based on technological solutions, to the best of our knowledge, pathways and systematic overviews of how social innovation can contribute to climate neutrality have not yet been conceptualized. The prototype provides a translation of abstract, complex and scattered knowledge into actionable possible futures, and can provide a basis for further improving and testing such synthesis of knowledge.

From a pragmatic perspective, the prototype enables policymakers to support collaborative strategizing on social innovation at an urban level, a tool for informed future making. The testing of the prototype contributes to improving the understanding of policymakers' need for an explorative and engaging modality (Jacob-Dazarola et al., 2020), allowing them to address wicked problems, such as social innovation in climate neutrality. The testing highlighted a misalignment in vocabulary between the (academic) designers and the users, which points to the need of contextualizing the communication of solutions to specific target users.

The creation of the prototype has led to the development of a theoretically grounded and practically relevant framework of potential social innovation pathways to climate neutrality at an urban level. The interactive actionable pathway tool can provide policymakers (deeper) insight into how social innovation can support climate neutrality, and act as a guide to understand the variety of choices available to a city's transition team as well as support the selecting of indicators for learning and measuring progress.

For designers, the methodology deployed for the creation of the prototype can provide guidance to synthesizing academic and pragmatic knowledge into a design outcome. In particular, the prototype serves as a means to surface users' mental models, implicit expectations as well as to envision a novel interactive modality for the target user (in this case, policymakers). In this context, the prototypes become not only a way to design and

refine a service, but also an object that supports and mediates the collaborative interaction between diverse actors.

Theoretical Implications

For policymakers, the prototype served as a boundary object (Star & Griesemer, 1989), enabling them to explore the social innovation actions that a city could implement. It also assisted in navigating the content of the NetZeroCities platform to gain more specific knowledge on topics of interest. For researchers, it provided a solid categorization of social innovation practices at an urban level, which are not only built on academic knowledge, but tested in practice-based contexts. The prototype mediated the dialogue (Bojer et al., 2008) and collaboration among researchers, designers, environmentalists, and urban transition teams (*Growth et al., 2020*).

The experiential knowledge acquired while creating, testing, redesigning and retesting the prototype (*Valentine, 2013*), allowed the development of a more solid theoretical framework, in addition to the practical tool. Through prototyping, the solution and the problem space have co-evolved (Dorst & Cross, 2001), supporting researchers in better refining the theoretical framework, by expanding the problem space to include motivational issue of the users. The prototype also allowed experts from different fields to visually connect their knowledge, exploring new cross-pollinations between social and environmental sciences. The process of collaboratively mapping interdisciplinary knowledge in the prototype is a goal in itself (*Growth et al., 2020*), which gives a tangible form to abstract - often siloed - knowledge.

Conclusion

The methodology for the prototyping provides an example of a successful aggregation of top-down scientific knowledge, bottom-up theorizing from case studies, users' needs and insights from collaboration with interdisciplinary experts and real-life user testing. Yet, this study is not free of limitations; the prototype still needs further refinement and further testing, in particular expanding the sample size, which would allow to account for the influences of contextual factors, such as the size of the city, the political will at urban and national level as well as language and cultural issues. Within the NetZeroCities project, the tool will be further developed and improved, and eventually made available to the 112 cities that are part of the project. In a VUCA (Volatility, Uncertainty, Complexity, and Ambiguity) world, design can provide a methodology to interact with complexity and make ambiguous, abstract knowledge more tractable, envisioning innovative solutions (Cousins, 2018), and imagine possible futures.

We believe the prototyping process enabled researchers to refine a theoretical framework, provided designers with a methodology to an unstructured novel topic, and policy makers with an interactive tool to support strategizing for leveraging people-based solutions for climate neutrality.

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