

Impacts beyond experimentation – Conceptualising emergent impacts from long-term real-world laboratory processes

Real-world laboratories are settings for joint experimentation on sustainability challenges, through the transdisciplinary collaboration of diverse actor groups. By approaching a real-world laboratory from three perspectives, this paper uncovers the emergent impacts of a long-term collaborative process.

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GAIA 33/S1 (2024): 18–25

Abstract

Real-world laboratories have become a recognised research format for addressing sustainability challenges. In these transdisciplinary settings, actors from civil society, local government, and academia work together using a transdisciplinary research approach to jointly experiment and learn about sustainability transformations. While these labs are considered to have potential, their impact has not yet been fully measured. Therefore, in our paper we explore the case of the *Zukunftstadt Lüneburg 2030+* process to uncover the impacts that this long-term effort has generated over the past eight years. By examining the process and its design features from three analytical perspectives, we identify emergent impacts in three dimensions: education, governance, and the lab as an actor for sustainability. Based on our case study, we suggest that real-world labs contribute to sustainability on a local level, beyond the intentional experiments, through impacts that emerge over the course of the joint operation of the lab.

Keywords

emergent impact, process design, real-world laboratory, transdisciplinary sustainability research, transformative research

Real-world laboratories (RwLs) are widely recognised and established as settings for collaborative and transdisciplinary research (Bergmann et al. 2021, Kanning et al. 2021, Parodi et al. 2021, Schöpke et al. 2018, Schneidewind et al. 2018). They are characterised by their orientation towards sustainability, and their long-term, transdisciplinary mode of collaboration, which provides a setting for the exploration of sustainability transformations through experimentation (Schöpke et al. 2018, McCrory et al. 2020). As settings in which different actors from science and society come together to collaborate, RwLs have been associated with a variety of benefits (Kok et al. 2023, Pärli et al. 2022). However, we view the discussion around the impacts of such research projects as being centred around the idea of an impact resulting directly from an intervention – as in the case of real-world experiments. While this perspective may be appropriate for real-world experiments, where the goal is to find causal links between interventions or sustainability solutions and outcomes, it is not necessarily suitable for assessing the impact of RwLs. Although there is a body of research into approaches for assessing the impacts of real-world experiments (e.g., Luederitz et al. 2017, Williams and Robinson 2020), the impacts generated as part of the collaborative RwL processes have not been studied in the same way.

In an attempt to fill this research gap, we suggest a revised approach for assessing RwL impacts based on our experiences in designing and participating in an eight-year RwL process in the city of Lüneburg. This approach is intended to complement the prevalent framing and understanding of impact, and to high-

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<https://doi.org/10.14512/gaia.33.S1.4>

Received May 23, 2023; revised version accepted December 22, 2023 (double-blind peer review).

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TABLE 1: Three analytical perspectives for assessing the impacts of the real-world laboratory (RwL) *Zukunftsstadt Lüneburg 2023+*. The analytical perspectives result from eight categories of impact^a suggested by Schäfer et al. (2021) and from the benefits of RWLs, as proposed in the literature.

CATEGORIES OF IMPACT	PROPOSED BENEFITS OF RWLS	ANALYTICAL PERSPECTIVES FOR ASSESSING THE RWL PROCESS
learning and capacity building	RwLs as places to facilitate learning (Singer-Brodowski et al. 2018, Beecroft 2018)	focus on educational features
<ul style="list-style-type: none"> ■ network formation ■ influence on law and regulations ■ further structural effects 	RwLs as places to establish inter-institutional collaborations (Marquardt 2019, Libbe and Marg 2021, Marg et al. 2019)	focus on collaborative governance features
<ul style="list-style-type: none"> ■ increase in reputation ■ continuation of activities in the project context ■ new concepts ■ influence on public discourse 	interactions and roles in transdisciplinary sustainability research, such as RWLs (Wittmayer and Schöpke 2014, Hilger et al. 2021)	focus on public interaction features

^aTwo of the ten impact categories from Schäfer et al. (2021) are only relevant at the level of experiments or interventions and are therefore not applicable at the RwL level. As such, the following two categories have been removed from our investigation: 1. improving the situation; and 2. transfer to other spatial contexts.

light its specific meaning in the context of long-term collaborative RwL processes. We start with the observation that the joint process of operating an RwL comprises many different iterative design features, such as activities, events, features, and actions, all of which follow their own purpose and achieve their own outcomes. Going beyond this, however, we are suggesting that the greater impact that these collaborative processes (and all their elements) make is better understood when approached as emergent; namely as an impact achieved through the combination and interplay of many individual design features and actions.

We aim to address the following research question: what impacts emerge from RwL processes? To investigate this question, we present the case of the RwL *Zukunftsstadt Lüneburg 2030+*, an RwL established in the city of Lüneburg by members of Leuphana University Lüneburg, the local city administration, and actors from civil society. The RwL was initiated in 2015, as part of the *Zukunftsstadt* funding programme¹ of the German Federal Ministry of Education and Research (BMBF), and was developed over three project phases: 1. a joint sustainability visioning process; 2. the collaborative development of solution ideas; and 3. the experimentation in an RwL setting.

We approach the lab process from three perspectives: 1. the lab as a space for learning and education; 2. the lab as a space for new governance structures; and 3. the lab as a public actor for sustainability, all of which we investigate as dimensions of potential impact. Through our approach, we identify and describe impacts that the joint work of the RwL has created in the Lüneburg context. We offer a novel perspective that complements the understanding of impacts as direct or indirect effects of intentional interventions. We conceptualise the impacts achieved in our RwL as emerging from different design features and their complex interplay as developed and implemented during the RwL process.

Approaching the impacts of real-world labs

The impacts of RwL processes are not easily identified. RwL processes are typically designed collaboratively, and they evolve over the course of their duration, adapting new goals, trying and failing with different actions and design features (Bergmann et al. 2021). Moreover, the many and diverse features of an RwL process are not all selected and implemented in pursuit of a larger impact goal. In many cases, the RwL adapts to the needs of the actors involved at any given point in the process. Consequently, a pre-post evaluative methodology is in many cases neither suitable, nor possible (Walter et al. 2007).

Therefore, our analytical approach integrates a number of theoretical understandings to approach these impacts (figure 1, p. 20). First, we adopt the understanding of transdisciplinary research impacts by Schäfer et al. (2021), as well as the proposed benefits of RWLs as discussed in the recent literature (McCrorry et al. 2020, Schöpke et al. 2018, Singer-Brodowski et al. 2018). Further, we adopt the analytical understanding by Wiek et al. (2014a). This approach recognises collaborative processes as drivers of impacts and aims to attribute these impacts to the participatory events of a given process. Integrating these understandings enables us to conceptualise the impacts that have emerged over the course of the long-term RwL process *Zukunftsstadt Lüneburg 2030+*.

In our case study, we present exemplary lab features as identified by the research team through joint reflection, building on the experiences from the research process, as well as synthesising available case data from the project documentation and communications throughout. To focus our investigation on the lab process, we disambiguate the lab process and the experiment following the approaches of Kampfmann et al. (2022) and Bernert et al. (2023): they view “experiments” as processes closely linked to the concept realisation of interventions, whereas “lab” describes the broader collaborative process that forms the conceptual context within which experiments are conducted.

¹ www.fona.de/de/massnahmen/foerdermassnahmen/wettbewerb-zukunftsstadt.php

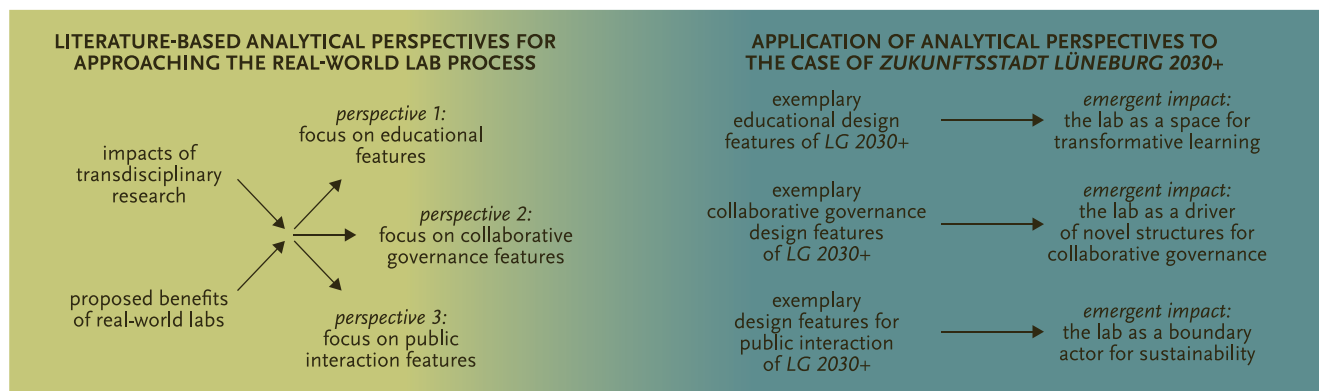


FIGURE 1: The research approach for uncovering and conceptualising impacts from the real-world lab process of *Zukunftsstadt Lüneburg 2030+* in Lüneburg, Germany. The perspectives are derived from the literature and then applied to our case to identify emergent impacts of the long-term process.

Societal impacts of transdisciplinary research: Three analytical perspectives for investigating real-world lab processes

Previous analytical papers on RwLs have focused on aspects such as the role of structuration (Schneidewind et al. 2018) or success factors (Bergmann et al. 2021), but they have not attempted to evaluate the impacts generated by operating a lab. Therefore, we base our understanding of such impacts, and their appraisal, on a number of approaches that have been put forward in the context of transdisciplinary and transformative research (e. g., Lux et al. 2019, Schäfer et al. 2021). Schäfer et al. (2021) systematise categories for approaching the societal effects of transdisciplinary research that can be differentiated as first, second, and third order effects depending on how closely the observed effects may be linked to the project under investigation. From this set of categories, eight are particularly suitable for assessing the impacts of the RwL itself (as opposed to the experiment level). Summarising these categories into three analytical perspectives enables us to describe the impacts of the *Zukunftsstadt Lüneburg 2030+* RwL (table 1, p. 19).

As shown (table 1), the impacts of transdisciplinary research identified by Schäfer et al. (2021) are matched with literature on the proposed benefits and qualities of RwLs to form the three perspectives on which we base our investigation. These benefits cover the notion that RwLs are spaces that facilitate different types of learning, which might “profit from a differentiated educational perspective for their methodological development, by systematically including learning as a characteristic of their design” (Singer-Brodowski et al. 2018). Moreover, RwLs create contexts in which governance arrangements (in the sense of inter-institutional collaborations between state and non-state actors) are established (Marquardt 2019) to foster societal problem-solving (Wolfram et al. 2019). By institutionalising transdisciplinary research in local contexts, the actors within RwLs may also represent diverse roles associated with this mode of research (Wittmayer and Schöpke 2014, Hilger et al. 2021).

Table 1 summarises our identification of the three analytical perspectives that stem from the impact categories by Schäfer et al. (2021) and the proposed benefits of RwLs. We focus our in-

vestigation of the *Zukunftsstadt Lüneburg 2030+* RwL process through the lens of these perspectives. In the following case study section (box 1, p. 21), we identify three exemplary process features for each of the perspectives. These features are then used as a reference for the emergent impacts that we conceptualise in each of the three perspectives.

Case study: Uncovering emergent impacts through three perspectives

In the following sections, we approach the *Zukunftsstadt Lüneburg 2030+* RwL process through the three perspectives as outlined above. We briefly introduce these perspectives, drawing on the RwL literature, and the impact categories suggested by Schäfer et al. (2021). We then reconstruct the process by presenting exemplary design elements. From these design elements and their individual contributions, we then abstract and conceptualise the related emergent impacts.

Perspective 1: Educational features of the lab process

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by the *close connection of activities in the lab with teaching and learning at the local university*. This aspect was central throughout the three project phases, and it unfolded in diverse ways, as demonstrated by the *inclusion of many educational features throughout the lab’s process*. We present and describe three such features in the table below (table 2, p. 21).

Emergent impact 1: The real-world lab as a novel space for transdisciplinary and transformative education and learning.

The experiences undergone in the *Zukunftsstadt Lüneburg 2030+* RwL address several levels of learning within RwLs, as conceptualised by Singer-Brodowski et al. (2018). The long process (over many years) leading to the creation of the *Zukunftsstadt Lüneburg 2030+* RwL opened up a window of opportunity for the development of students’ individual competences (i. e., system and anticipatory thinking), which was strongly fostered through ex-

BOX 1: The *Zukunftsstadt Lüneburg 2030+* real-world laboratory (RwL)

Lüneburg is a medium-sized town of about 80,000 residents, located within the Hamburg metropolitan area. The *Zukunftsstadt Lüneburg 2030+* RwL was established as a result of a long-standing and continuously evolving collaboration between actors from the city administration, the civil society, and the university (Bernert et al. 2016). Due to the logic of its public funding line, the RwL consisted of three subsequent phases: 1. from 2015 to 2016, a large-scale visioning process for a sustainable city in the year 2030 and beyond; 2. from 2017 to 2018, the participatory and transdisciplinary development of 17 sustainability solution strategies; 3. from 2019 to 2023, the realization of 15 real-world experiments building on the solution strategies. As of 2019, the process was closely linked to, and officially intertwined with, the formation of a city-wide integrated development concept (ISEK), initiated by the city council of Lüneburg^a (Hansestadt Lüneburg 2019).

Despite its inherently open and evolving character, the *Zukunftsstadt Lüneburg 2030+* RwL was designed along general principles, including a strong sustainability orientation due to the framing of the project as a local implementation and interpretation of the *Sustainable Development Goals*. The establishment of a steering group, tasked with democratically making all the basic project decisions, was a key feature of the overall

project design. The steering group consisted of members from the city administration, the university, and the civil society.

The collaborative process of *Zukunftsstadt Lüneburg 2030+* in all three project phases combined open work phases in different group constellations (e.g., sharing visions for the future in student-stakeholder teams), as well as work steered and conducted by the project team (e.g., to integrate interim results). Each phase ended with a large-scale participatory event (the so-called *Zukunftstadt-Tag*). Students from the local university were closely involved in all the stages, and they contributed their own perspectives from their studies in different areas. In parallel to the project, a case study office was installed to support the students' research and the teaching endeavours (Kirst et al. forthcoming).

The 15 real-world experiments conducted in the third phase were designed to address a variety of sustainability issues in the city, such as sustainable logistics and mobility in the local economy, youth participation for sustainability, supporting biodiversity efforts of civil society initiatives, or the sustainable design of public spaces.

^aChrist et al. (2024, in this issue) present an evaluation of another long-term urban RwL in Flensburg, Germany.

experience-based (Caniglia et al. 2016) and project-based (Wiek et al. 2014b) teaching and learning settings. This also facilitated social learning processes that supported collective meaning-making and reflexivity (Singer-Brodowski et al. 2018). The normative orientation created learning opportunities for both students and other actors in the project, in the sense of individual learning (e.g., normative thinking), as well as social learning (as it po-

tentially led to a higher level of reflexivity) and the capability to jointly deal with mistakes in an iterative collaborative process (Singer-Brodowski et al. 2018). The strong focus on linking the RwL with teaching activities at the local university was a key design feature in this respect, and one that led to emergent impacts in both directions within the educational-research sphere. The RwL created a fruitful learning environment for the students in-

TABLE 2: Exemplary educational design features of the real-world lab (RwL) process for *Zukunftsstadt Lüneburg 2030+*.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE ^a
higher education teaching continuously embedded in the project	<ul style="list-style-type: none"> ■ continuous student involvement based on inter- and transdisciplinary study model ■ experience-based teaching alongside real-world developments in the RwL (e.g., co-developing sustainability visions; supporting the realisation of experiments) 	<ul style="list-style-type: none"> ■ >1500 students of all levels were involved in project-related teaching ■ many results are documented in a case study database 	Barth et al. 2017, Weiser et al. 2023
development of new teaching formats relating to the RwL	<ul style="list-style-type: none"> ■ lab as context for the development of new teaching formats, in established curricula and new learning modules (e.g., the <i>Transformative Innovation Lab</i>) 	<ul style="list-style-type: none"> ■ new teaching models and seminar designs deeply involving students in lab and experiments ■ principles for the design of transformative teaching 	Bernert et al. 2022, Wanner et al. 2021, 2020
capacity-building around sustainability as a reoccurring lab activity	<ul style="list-style-type: none"> ■ capacity-building for sustainability among the core project members and with external actors and visitors ■ continuous reflection of sustainability understandings in context of current developments in Lüneburg (e.g., COVID-19 pandemic) ■ regular visits from researchers (e.g., tdAcademy; PostDoc Academy, international consortia) as capacity-building formats and to support reflexivity within the project team 	<ul style="list-style-type: none"> ■ capacity-building with three cohorts of 20 participants each in the Postdoc Academy ■ adaptable teaching materials as introductions to the RwL approach within the project 	Postdoc Academy for Transformational Leadership ^b

^aFurther readings and project-related sources related to the design feature. | ^bwww.bosch-stiftung.de/en/project/postdoc-academy-transformational-leadership

volved, while the students' activities also helped to support and advance the RwL itself. At times, these activities developed their very own dynamic that contributed to social learning processes far beyond the classroom. In this way, the RwL established a space for fostering transformative transdisciplinary learning and further developing teaching approaches.

Perspective 2: Design features fostering collaborative governance

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by *close collaboration between members of the city administration, the civil society, and the university*. This aspect was central throughout the three project phases and unfolded in diverse ways (table 3). Together, these developments have created an emergent impact that can be conceptualised as establishing the *Zukunftsstadt Lüneburg 2030+* RwL as a *novel institutionalised form of collaborative governance* (for sustainability) in its surrounding local context.

Emergent impact 2: The real-world lab as a driver of novel structures for collaborative governance

While the collaboration between the civil society, the city administration, and the university has a long-standing history in the city of Lüneburg, the RwL process of the *Zukunftsstadt Lüneburg 2030+* has institutionalised and deepened this mode of joint collaborative governance. The RwL has helped to establish both formal and informal networks between state and non-state actors, as well as fostering political plans and structural changes. *Zukunftsstadt Lüneburg 2030+* can be seen as a context in which urban stakeholders could expand their capacities for advocating for urban sustainable development in the future. Through their engagement in the RwL process, members of Lüneburg's city administration were able to gain experience in the fields of inclusive, multiform, urban governance, as well as creating visions for the future and experimenting with sustainability solutions.

Both are crucial components of the urban transformative capacity framework (Wolfram et al. 2019, Castán Broto et al. 2019). The *Zukunftsstadt Lüneburg 2030+* RwL created impact through forming, as well as consolidating, urban transformative capacity, which in turn led to the creation of informal networks, influenced political agendas, and altered the formal structures for fostering sustainability and citizen engagement.

Perspective 3: Design features for public interaction

The RwL process of *Zukunftsstadt Lüneburg 2030+* is characterised by the *close involvement of Lüneburg residents* throughout the three project phases. This involvement was enabled through many design features, which unfolded in a variety of ways. These are presented in this section (table 4, p. 23). Together, these developments created impacts that can be conceptualised as establishing the *Zukunftsstadt Lüneburg 2030+* RwL as a *novel boundary actor for sustainability in its local context*.

Emergent impact 3: The real-world lab as a boundary actor for sustainability

Due to its implementation of diverse activities with a strong focus on public involvement in the context of sustainability questions, we argue that the RwL gained the role of a public boundary actor for sustainability during the project. As a boundary actor, the lab was able to foster active networking among local actors and support numerous sustainability-oriented initiatives by civil society actors, as well as local businesses. By facilitating (and occasionally mediating) the public exchange on sustainability issues, the lab acted as a hub to connect actors with administrative representatives, researchers, and other actors and initiatives. Complementing the efforts of a diverse landscape of sustainability initiatives, the lab institutionalised many of the roles attributed to transdisciplinary researchers (Wittmayer and Schöpke 2014, Hilger et al. 2021).

TABLE 3: Exemplary design features of the *Zukunftsstadt Lüneburg 2030+* real-world lab (RwL) process fostering collaborative governance.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE ^a
joint leadership of the RwL process	the RwL process is carried out by the city administration, the university, and local civil society	decisions on structural changes in the city administration were discursively linked to the RwL process	Purschwitz 2023
biannual advisory board meetings	<ul style="list-style-type: none"> ■ the RwL board consisted of members of political parties on the city council, interest groups, and university representatives ■ RwL experiments and further work were discussed at meetings 	transdisciplinary working approach and group composition were transferred to a novel project focusing on a resilient city centre	Hansestadt Lüneburg 2021
connected to the Integrated Urban Development Process (ISEK)	RwL and ISEK processes were intentionally linked to each other (e.g., represented in one brand)	<ul style="list-style-type: none"> ■ learning from evaluations of the events held during the RwL process ■ ISEK events were located in isolated city districts to gather the opinions of residents from those areas 	Hansestadt Lüneburg 2019

^a Further readings and project-related sources related to the design feature.

TABLE 4: Exemplary design features of the *Zukunftsstadt Lüneburg 2030+* real-world lab (RwL) process for public interaction.

DESIGN FEATURES	DESCRIPTION	DIRECT OUTCOMES	LITERATURE ^a
large-scale public events	<ul style="list-style-type: none"> large public events (e.g., <i>Zukunftsstadttage</i>) during all project phases to educate about the project and invite actors to participate during the COVID pandemic, <i>Zukunftsstadt-magazine</i>: broadcast events involving experts and local representatives discussing sustainability in Lüneburg and beyond 	<ul style="list-style-type: none"> different event formats have reached up to 2,000 people the opening day of the third phase was attended by 300 to 400 people 	<i>Zukunftsstadt-magazine</i> available on www.youtube.com/@Leuphana
RwL as a service agency	<ul style="list-style-type: none"> both steering committee and lab activities were designed to be open to citizens and actors interested in collaborations RwL promoted direct connections with local actors and occupied a central position between the actor groups, the city administration, and the university realisation of this role was supported through formats such as open-office days 	<ul style="list-style-type: none"> support for new alliances and initiatives (e.g., <i>Tauschregal</i>, setting up open exchange shelves for unused goods) recognition of <i>Zukunftsstadt</i> as a strong local actor 	internal meeting minutes
continuous information about the project's sustainability activities and cooperation with other actors	<ul style="list-style-type: none"> regular information through newsletters and monthly pages in the local newspaper, <i>Landeszeitung</i>, to report on project activities and sustainability initiatives in Lüneburg creation of the shared brand <i>Lüneburg. Die Zukunftsstadt.</i> for the RwL and ISEK process social media presence on Instagram to inform about the project's progress and activities in Lüneburg 	<ul style="list-style-type: none"> continuous information of general public about sustainability activities using diverse channels of communication (e.g., newspaper with a circulation of over 20,000, Instagram page with over 1,500 followers) 	Purschwitz 2023

^a Further readings and project-related sources related to the design feature.

Towards an understanding of emergent impacts of real-world labs

In our case study, we identified several impacts of a long-term RwL process. By reflecting on the eight-year process of the *Zukunftsstadt Lüneburg 2030+* project, we uncovered and conceptualised the impacts in three dimensions.

1 Emergence as an inherent quality of the impacts of collaborative processes. The impacts we identified, while not accidental, were not planned for at the beginning of the process and were not achieved due to a specific experiment or intervention. Instead, they emerged from a continuous, collaborative process between the city administration, the civil society, and Leuphana University Lüneburg. All of these participants brought their interests, motivations, and capacities to the process of jointly operating a lab that aimed to contribute to a local sustainability transformation. As we have illustrated in our case study, the process of operating a lab comprises many diverse and small-scale design elements that together build the long-term complex process that is *Zukunftsstadt Lüneburg 2030+*.

However, approaching these single design elements from a cause-and-effect perspective would not enable a reflection of these larger impacts that are, in our view, crucial for answering the question: “Why use RwLs?”. We are aware that the concep-

tual impact understanding we offer may not meet the desire to quantify the impacts of RwL research. Explicitly recognising emergent impacts may, however, serve to complement such a perspective, providing a space to reflect upon “success” (in the sense of local contributions and transformative change enabled through its operation) and the transferability of process features. Furthermore, the recognition of RwL impacts beyond the experiment supports their further development as institutions that are not just experimental extensions of transdisciplinarity, or spaces for innovation testing (Parodi 2019).

2 Using an emergent impact understanding in RwL design. Future labs may use descriptions of emergent impacts from other labs, not to rebuild the exact same process, but to formulate more differentiated understandings of desired impacts. This could support a deeper shared understanding of the interests, perspectives, and capacities present among actors in the lab to develop a more future-oriented guiding perspective. Thus, while the impacts at the lab level may remain difficult to grasp from a cause-and-effect perspective, the practice of describing and conceptualising these impacts may make them more tangible. This could serve to better align certain design choices with, on the one hand, day-to-day realities (e.g., semester planning, “Vereinsarbeit” or voluntary work, the daily tasks of a city administration) and, on the other hand, with the overall objectives of the RwL.



While the impacts that have emerged from the *Zukunftsstadt Lüneburg 2030+* case are strongly intertwined with the local context, we argue that the dimensions in which these impacts lie – labs as spaces of transformative learning, labs as collaborative governance arrangements, and labs as boundary actors – are also relevant for better understanding the value and contribution of RwL processes in other contexts. Moreover, by presenting the design features in addition to the emergent impacts, we have also aimed to provide insights regarding the “knowledge how” (Caniglia et al. 2020).

3 Developing new methods for impact assessment. The methods for capturing and conceptualising emergent impacts of RwLs need to be further refined and integrated with similar approaches (Marg et al. 2019, Schäfer et al. 2021). Our tentative analysis has integrated different theoretical considerations to identify impacts by adopting three perspectives. This should be further explored in close cooperation with other RwLs to identify further emergent impacts. Future research could also focus on adequate approaches for the creation of stronger evidence bases for such impacts. However, we are convinced that one strength of our tentative analysis lies in the recognition of the crucial design features of RwL research.

With our contribution to the debate around the impacts of RwL research, we hope to highlight the value of engaging with the emergent impacts of RwLs. We look forward to future developments in this field and to the creation of effective tools for capturing and further conceptualising these impacts.

Acknowledgement: We thank all the people who have been involved for many years in jointly shaping and carrying out collaborative real-world lab work in and around Lüneburg. We especially thank our colleague *Antje Seidel* for her contribution to the development of this article and collaborative work in recent years within the *Zukunftsstadt Lüneburg 2030+* project. Furthermore, we would like to thank the two anonymous reviewers for their time and effort in reviewing the manuscript. We sincerely appreciate their comments, which have helped us to improve this article.

Funding: German Federal Ministry of Education and Research (BMBF), funder id: 10.13039/501100002347 (grant no: 13ZS0058B).

Competing interests: The authors declare no competing interests.

Author contribution: PB, AW, TK: research design, original draft of the manuscript; PB, AW, TK, DL: final manuscript.

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