Learning in Real-World Laboratories
A Systematic Impulse for Discussion

Real-world laboratories (RwLs) are a form of transdisciplinary research that facilitates learning processes as part of its transformative objectives. Nevertheless, little conceptual effort has been put into the understanding, planning, and evaluation of the learning dimension of RwL work. This paper applies a systematic approach from the discourse on education for sustainable development (ESD) to differentiate three perspectives on the various learning processes occurring in RwLs and exemplifies them with experiences from the RwL Urban Transition Lab 131 in Karlsruhe.

As an approach for transformative research, real-world laboratories (RwLs) have gained growing attention in the past few years. RwLs are part of an experiential turn in social science in general (Overdevest et al. 2010) and a solution-oriented research agenda in sustainability science (Miller et al. 2014, Wiek and Lang 2016). They have been conceptualized as “places of learning” (Parodi et al. 2016b, p. 10, own translation; Beecroft and Parodi 2016a, p. 7) or “societal context (...) to learn about social processes” (Schneidewind 2014, p. 3, own translation). Schäpke et al. (2018, in this issue) even see learning as a core characteristic of RwLs, since it fosters the individual and collective capacity to deal with challenges and differences and thereby supports the transformative objectives of RwLs. However, little is known about their potential to facilitate learning. As more and more RwLs are being set up (Beecroft and Parodi 2016b), questions arise regarding, for example, the potential of RwLs for social learning and education for sustainable development (ESD) (e.g., Schneidewind and Singer-Brodowski 2015).

To start a systematic discussion, we address RwLs from a combined didactical and methodological perspective (Beecroft and Dusseldorp 2012), conceptualizing them as “learning environments”. We apply a conceptual framework that describes the contribution of educational science for sustainability science in general, differentiating three theoretical perspectives (Barth and Michelsen 2013). The distinction between individual competencies, social learning, and inter- and transdisciplinary cooperation serves as an analytical tool for the first goal, to map out the potential RwLs carry for facilitating learning. The second goal is to include “learning” as a dimension to the methodological and self-reflexive discourse on RwL research, following the same framework.

After outlining our understanding of an RwL, we will present the analytical framework and apply it to RwLs. Early experiences from one RwL in Karlsruhe will serve to illustrate the analysis. We will conclude with a systematic overview on the mutual benefits between learning, transformation and research in RwLs.

Real-World Laboratories
To achieve transformation, various societal actors have to learn new perspectives, skills, competencies, practices and develop new concepts of their own role. Transformative research (see Schäpke et al. 2016), such as RwL research, should embrace this necessity to enable learning processes and reflexivity as a key dimension of their methodology.

In the flagship report of the German Advisory Council on Global Change, RwLs are defined as “scientifically designed spaces of collaborative sustainability research involving intervention” (WBGU 2016, p. 512). Further definitions of RwLs (Parodi et al. 2016b, Beecroft and Parodi 2016b) have been developed in a broader theoretical-conceptual discussion between RwL practitioners, including a university course on RwL research. They highlight

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Seven key characteristics: 1. research orientation, 2. normativity, 3. transdisciplinarity, 4. transformative approach, 5. inclusion of civil society, 6. long-term orientation, and 7. lab character both in terms of local contextualization and experimental strategy. These characteristics distinguish an RwL from similar approaches (see also Parodi et al. 2016a, Schäpke et al. 2017). They can be found in several operating RwLs (e.g., the BaWi Labs, see Parodi et al. 2018, in this issue) and are used here to explore the relation between an RwL and learning in a structured way.

**Individual Competencies for Sustainability**

The first contribution of educational science addresses individual learning and more specifically the individual competencies for engaging in sustainability transformations. The overall debate about competencies for sustainability transitions has identified anticipatory, normative, system thinking, strategic, and interpersonal competencies as decisive (Wiek et al. 2011). A learning environment addressing real-world sustainability problems can support learners to develop these competencies. An RwL offers such an authentic context. Here, learners can become part of solution processes, in the areas of both research and practice (Wiek et al. 2014). They can apply theoretical knowledge to a specific problem and generate new knowledge by translating experiences into more abstract concepts (Schneidewind and Singer-Brodowski 2015, p. 12). This two-sided process can be described as an experiential learning cycle (Kolb 1984), with the interplay of knowledge exchange, action, and reflection at its core. Such a learning cycle corresponds closely to the experimental and reflexive approach of RwL research.

Following such a perspective, an RwL running transdisciplinary (3) and transformative (4) processes serves as a learning environment for individual competency development. It is particularly the experimental approach which can lead to competency development of the individual learner embedded in an evolving social community (Wiek and Kay 2015). From an educational perspective, one can derive the necessity to address the individual competency development actively. In RwL research, we suggest

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**Box 1: Urban Transition Lab 131 (R131)**

The Karlsruhe Institute of Technology (KIT) established the R131, which aims to achieve a dense sustainable development of the district Karlsruhe Oststadt in a transdisciplinary process. The objectives are transformation, research, and educational aspects. Scientific aims are the generation and testing of knowledge required for a sustainable transformation of existing cities. The lab runs eight real-world experiments (RwE), four mainly driven by scientists (energy concept, mobility, social issues and urban space, sustainable consumption) and four mainly driven by citizens (*Your Sustainability Experiment*). The lab also offers transdisciplinary project courses (see below). The RwEs are accompanied by a sustainability assessment. The lab serves as a learning environment, networking platform and infrastructure, enabling sustainability experiments arising from the district’s needs and interests.
to jointly explicate learning goals in advance. This is advisable not just for students in university courses, but also for practice partners and scientists involved, ensuring individual competency development for all groups. Based on the elaboration of these learning goals, planning knowledge exchange, action and reflection can incorporate didactical aspects, that is, through time-slots for personal and theoretical reflection or communication techniques to enhance mutual understanding. The achievement of the learning goals should also be included into the evaluation process, at least ex post. Both the long-term orientation (6) and the lab character (7) of RwLs can be used to facilitate learning beyond singular interventions and experiments and adapt the RwLs experimental and interventional methodology accordingly.

R131 in Karlsruhe uses transdisciplinary project courses to facilitate learning, practical, and scientific outcomes in one integrated format. In these courses, students are being encouraged to explicate their individual learning goals in advance, and reflect upon the outcomes of their projects in terms of practical results, theoretical findings, and individual learning. This “goal triangle” was used both as a basis for decisions in the project work and for identifying necessary support from the teaching staff. At the end of the project course, these expectations are being used to assess the outcomes of the course from a participant’s perspective: in learning portfolios, students reflect upon their own diverse learning outcomes. These portfolios usually entail the participants’ level of personal competencies, their knowledge on the exemplary subject, surprises, and often link to their experience in local civil society organisations (CSOs). Sometimes, the expectations for mutual learning with other stakeholders become clear only ex post.

Social Learning
The second contribution of educational science is to identify, describe and understand the various informal processes of joint or mutual learning between actors from diverse backgrounds in terms of “social learning” (Barth 2015, p. 163ff., Pahl-Wostl and Hare 2004, Keen et al. 2005). This theoretical perspective frames processes of heterogeneous stakeholders – individuals or groups – interlacing their perspectives and coping with conflicting aims as learning together (Pahl-Wostl et al. 2007). Although the actors also develop individual competencies in these processes, the social learning perspective focuses on assumptions and values underlying groups or a whole social system. The underlying assumptions can be described as meaning perspectives in terms of orienting cognitive and perceptual frames, which aim at structuring perceptions and experience (Mezirow 2000). Social learning is “an intentional process of collective self-reflection through interaction and dialogue” (Fernandez-Gimenez et al. 2008). Through building a common learning environment, RwLs can offer an ideal space for analyzing and negotiating divergent meaning perspectives, thereby going beyond given assumptions and in the end leading to higher reflexivity.

The experimental mode (7) of work in RwLs allows for mistakes, iterations, and changes. RwLs thus support a livid learning culture and enable reflexivity. In most cases, scientists initiate and run RwLs, emphasizing their research potential. Nevertheless, they can also create joint learning occasions for people from different backgrounds and sharpen their perspectives on further elements of social learning: the identification of the participants with sustainability solutions through a process of collective meaning making. RwLs facilitate the participation of various stakeholders because of their strong civil society orientation (5), and have the potential to nurture ownership of the sustainability issue at hand. They can include not only established organizations but also informal and loosely coupled networks working on the solution of a singular sustainability problem. Especially this organizing principle of RwLs – and their internal structures, such as experiments, groups, etc. – can play a crucial role in framing RwLs as a learning environment for adults. It is an informal setting focused on one sustainability problem and open for engaging various non-university actors in RwLs across all age groups. The explication of normativity (2) – ideally as an elaborate concept of sustainable development – can play an important role to stimulate these negotiations and learning processes in RwLs.

The educational perspective of social learning can inspire RwLs to take a step back and look at the many-faceted processes of communication, negotiation, and learning that take place in the lab, to assess, support, evaluate, and sustain them. Educational science has inspired a broad range of methods to facilitate and enable such social learning processes (i.e., moderation, reflexive elements, non-violent communication, theatre of the oppressed, socratic discourse).

In R131, the competition format Your Sustainability Experiment (Meyer-Soylu et al. 2016, Trenks et al. forthcoming) has been developed, in which small groups of stakeholders carry out self-experiments, receive organizational support, regarding, for example, visibility, networking, internal working processes, and minimal funding. Their projects are closely monitored by an accompanying research team, serving both as facilitators and as scientific counterpart: individual and social learning complement each other. The close cooperation makes the process accessible for evaluation, even though the project design was not systematically based on educational theory. A first analysis shows that the engaged citizens do not necessarily differentiate between their learning outcomes and practical outcomes, they see them as closely linked.

Inter- and Transdisciplinary Collaboration
The third contribution of educational science – conceptualizing the modes of inter- and transdisciplinary collaboration – describes the cooperation both between disciplines and between science and other stakeholders as a “community of practice” (Lave and Wenger 1991). Learning is understood as a contextual and situated practice rather than as a purely cognitive process. Developing expertise through learning does not only encompass understanding the respective community of practice (or forming a new one), but also the transformation of one’s own role and language.

RwLs are spaces that establish communities of practice to facilitate intense interactions between researchers and practitioners, in line with their abovementioned research orientation (1).
transdisciplinarity (3), and shared aim for transformation (4). In
dependent communities face the task of familiarizing themselves
with each other’s practice to facilitate mutual learning and, subse-
quently, the integration of different forms of knowledge. By con-
fronting, interrelating, and integrating different epistemic cultures
(Knorr Cetina 1999)3, RwL research can lead to an experience of
epistemic difference. It can, however, also help to re-integrate ep-
istemic cultures bound to different roles, for example, as a neigh-
bour, a scientist and a member of a CSO. The special mode of ex-
perimenting and intervening in real-world processes bears addi-
tional challenges. These encompass the danger of frustrating in-
volvement, for example, through too academic approaches, in-
tegrating the findings of different experiments on a very abstract
level, and the challenge of letting go in processes of empowerment.

From a perspective based on educational sciences, a key aim is
to prevent the stabilization of mutual stereotypes through the ex-
perience of epistemic difference. Reminding actors of their mul-
iple roles and offering a protected space to establish mutual trust
and give room for self-reflection which can – at times – be very
challenging, are typical strategies to cope with these issues.

In the R131 experiment Sustainable Energy Concept for Karlsruhe
Oststadt, electrical engineers, who never worked in an inter-
or transdisciplinary manner before, were involved in highly unfamil-
iliar processes over 18 months: co-designing the experiment with
citizens, cooperating with scholars from social sciences and hu-
mans, and carrying out citizen workshops. In doing so, vari-
ous processes of mutual learning have taken place and the expe-
riences have deeply affected their own role, language(s) and self-
conceptions. However, not all engineers interested to take part in
the experiment in the first place felt comfortable with the experi-
ences of epistemic and cultural difference. Several of them did not
want to give up their role as distanced scientists. In consequence,
the R131 team plans to include training events already for poten-
tial participants, preparing them for the experience of epistemic
difference and their changing or overlapping roles in the trans-
disciplinary process.

Real-World Laboratories Facilitate and Profit from Multi-Faceted Learning Processes

From an educational perspective, we have conceptualized RwLs
as learning environments that facilitate learning on three inter-
connected levels, personal competency development, social learn-
ing, and inter- and transdisciplinary collaboration. This perspec-
tive can describe existing and inspire new methodological strate-
gies for RwLs, both to enable learning within RwLs and to advance
RwL research as it shows close links to the seven core character-
istics of RwLs. Table 1 gives a brief overview of the mutual bene-
fits with exemplary contributions.

This brief systematic impulse for discussion shows that RwLs
offer a potential for learning and that they can, in turn, profit from
a differentiated educational perspective for their methodological
development, by systematically including learning as a character-
istic of their design. Further research on the inclusion of educa-
tional concepts and methods in RwLs is required, for example,
relating to the feasibility of learning aims as part of (formative)
evaluation processes, the competencies required for RwL research,
and the continuous transformation of an RwL as a learning pro-
cess in its own right.

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3 The term “epistemic cultures” refers to those sets of practices, arrangements,
and mechanisms “bonded through affinity, necessity, and historical coincidence
– which, in a given field, make up how we know what we know. Epistemic cultures
are cultures that create and warrant knowledge” (Knorr-Cetina 1999, p. 1).

4 This can represent a situation when a person is confronted with different
epistemic cultures (i.e., of disciplinary scientific communities, which may be
inconsistent or contradictory to the epistemic cultures of the own discipline
or the perspectives of practitioners) and starts to reflect upon them.
References
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