

DOSSIER

Creating Learning and Teaching Spaces for Transformative and Transdisciplinary Research: The Transformative Innovation Lab

Creación de espacios de aprendizaje y enseñanza para la investigación transformadora y transdisciplinar: el Laboratorio de Innovación Transformadora

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ABSTRACT

For achieving a transition towards sustainable development, central importance is attached to science and education, and especially higher education. Suitable formats are needed for empowering students to perform transformative research. On the basis of transdisciplinary and transformative real-world laboratory research and futures studies, we develop encompassing learning and teaching module: the Transformative Innovation Lab (TIL). The lab builds on insights into five key competencies and three types of knowledge needed for developing socially robust sustainability innovations. In this paper, the main features of this experiential and reflexive format are presented and linked to a handbook for facilitating the lab. Central learnings for implementing the format in existing study programmes from two test runs at two German universities are shared and discussed.

Keywords: Education for Sustainable Development; Transdisciplinarity; Transformative Research; Real-World Laboratories; Futures Studies; Key Competencies for Sustainability.

RESUMEN

Para lograr una transición hacia el desarrollo sostenible son fundamentales la ciencia y la educación, especialmente la educación superior. Se necesitan formatos educativos para capacitar a los estudiantes en la realización de investigaciones transformadoras. Con base en la investigación transdisciplinaria y transformadora en laboratorios del mundo real y estudios del futuro, desarrollamos un módulo de aprendizaje y enseñanza integral: el Laboratorio de Innovación Transformadora (LIT). El laboratorio desarrolla cinco competencias clave y tres tipos de conocimiento necesarios para desarrollar innovaciones en sostenibilidad socialmente robustas. En este artículo se presentan las principales características de este formato vivencial y reflexivo, además de un manual para facilitar el laboratorio. También se comparten y discuten los aprendizajes centrales de la implementación de este formato en programas de estudio existentes a partir de dos pruebas realizadas en dos universidades alemanas.

Palabras clave: Educación para el desarrollo sostenible; transdisciplinarietà; investigación transformadora; laboratorios del mundo real; estudios del futuro; competencias clave para la sostenibilidad.

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Introduction

Despite a range of global advancements in transitioning towards a liveable and intact world (UN, 2015c), socio-environmental topics such as poverty, inequality, or climate change continue to be pressing and all too often growing problems (Steffen, Richardson, et al., 2015; Steffen, Broadgate, et al., 2015). Against this backdrop, the international community in 2015 adopted the Agenda 2030 for Sustainable Development—a plan for fundamental improvement in current and future life-styles and the protection of natural resources (UN, 2015b). For the agenda to be achieved, central importance is attached to science and education, and especially higher education with its university teaching and learning formats (UN, 2015a, 2015b; WBGU, 2011). An understanding of the complexity, uncertainties, trade-offs, and risks associated with local and global sustainability challenges is considered crucial to foster sustainable social development (Leicht et al., 2018). Education for sustainable development (ESD) thus focuses on developing the key competencies that enable individuals to help shape and

guide societal development processes in a sustainable direction.

In the realm of science, such active, normative-oriented approaches and modes have been distinguished in transformation research and transformative research by the WBGU (2011). Transformation research aims at understanding both causal factors and drivers of as well as obstacles to transformation processes in order to draw conclusions about future developments and how to shape them. The aim of transformative research, on the other hand, is to try out sustainability solutions in interventions and to learn in the course of application (WBGU, 2011, pp. 321 ff.).

In this line of thought, according to Hirsch Hadorn et al. (2006) three types of knowledge are central to the understanding and design of sustainability transformations: systems knowledge, target knowledge, and transformation knowledge. Systems knowledge is understood as providing an “objective” understanding of systemic relationships. Target knowledge produces knowledge on desirable and hence normative futures. Research on and about these two types of knowledge is typically asso-

ciated with transformation research and is considered to be descriptive and explanatory. The third type, transformation knowledge, extends far into the territory of transformative research, where context and actor-specific knowledge about possibilities for shaping transformation processes that are effective in terms of sustainability is tested, developed, and applied in collaborative and experimental processes.

Developing and being able to use these types of knowledge requires special training. Therefore the question arises of how to enable students to perform transformative research and become a sustainability change agent. In this paper we will propose a step-by-step learning module that helps students to unlock their transformative research potential. We will first introduce the conceptual foundations of the module and describe the state-of-the-art of transformative, transdisciplinary and real-world laboratory research as well as futures studies. We will then draw on a framework of key competencies for shaping sustainability. From there, the format of the Transformative Innovation Lab (TIL) is derived and presented. Insights into and learnings from two test runs of the format are given. We will close with a critical discussion and open questions on teaching transformative and transdisciplinary research in higher education.

Transformative and transdisciplinary research approaches

The question of how science can contribute to surmounting the global challenges described is a leitmotif of sustainability research and has led to a profound reflection process within the scientific community, especially since the 1990s. Building on action research, solution-oriented and interventional research designs were discussed and developed in what is known as Mode-2 research (Gibbons et al., 1994; Nowotny et al., 2001; Schneidewind et al., 2016). Transdisciplinary research (TDR) has been developed as a fruitful mode to tackle sustainability issues (e.g. Hirsch Hadorn et al., 2008; Lang et al., 2012; Scholz & Steiner, 2015; Thompson Klein, 2004) and essentially encompasses three characteristics:

- TDR addresses problems relevant to society,
- enables shared learning processes and integrates knowledge from scientists in different disciplines and notably also from outside the scientific community, and
- aims to produce solution-oriented, socially robust knowledge that can be transferred both into society and into science.

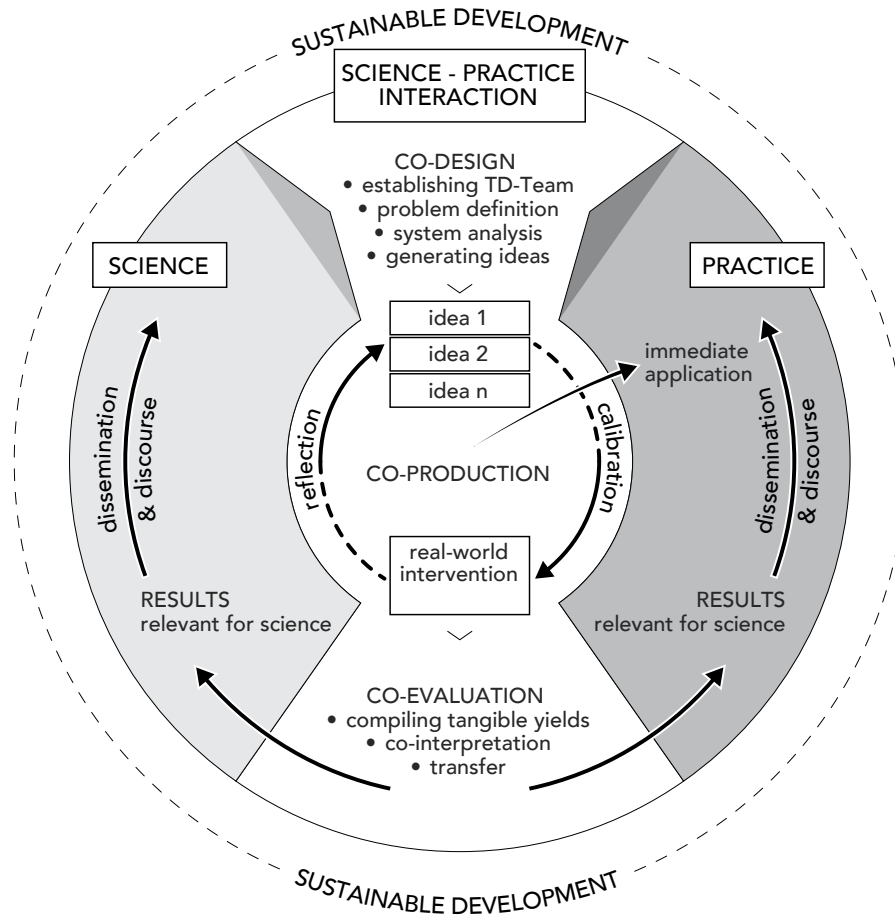
The ideal-typical model of TDR based on Lang et al. (2012) proposes three phases. The first phase primarily serves the purpose of specifying and framing a shared understanding of a problem and building a suitable project team. The aim of the second phase is to integrate different bodies of knowledge in order to co-create solution-oriented, transferable knowledge. The final phase is about reintegrating and applying the knowledge integrated in the research process. This two-dimensional reintegration transfers the knowledge back to the scientific community and to societal practice.

Real-world laboratories as a setting for transdisciplinary and transformative sustainability research

In the last years, new experimental and contextualized research approaches have taken hold, trying to push innovation for sustainable development (Berkhout et al., 2010; Bulkeley & Castán Broto, 2013; Fuenfschilling et al., 2019; Nevens et al., 2013). The framing of such real-world experimentation as real-world laboratories is the most elaborated variant when it comes to adopting the history and process qualities of TDR (Bergmann et al., 2021; Schöpke et al., 2018; Wanner et al., 2018).

Real-world laboratories systematically connect transdisciplinarity and transformation research, and mark the intersection between transformation research and transformative research. The focus of real-world laboratories is on experimentation, which implies the application of knowledge and cyclic learning on the basis of that knowledge in the course of the research process (see Fig. 1).

Figure 1
 Concept for a transdisciplinary and transformative real-world lab process
 focused on learning from experiment.



Adapted from: "Towards a Cyclical Concept of Realworld Laboratories: A Transdisciplinary Research Practice for Sustainability Transitions", by M. Wanner et al., 2018, *disP - The Planning Review*, 54(2), p. 102.

The chart shows the ideal-typical process of a real-world lab with the phases co-design, co-production, and co-evaluation. This process logic guided the conceptualisation of the learning phases in the Transformative Innovation Lab (see Fig. 1).

In this process, real-world laboratories follow an approach of transdisciplinary collaboration between scientists and (local) practitioners, integrating different forms of knowledge and jointly organised participation and learning projects, including in the form of exploratory learning. Research in real-world laboratories mainly takes place in context. The process also enables ongoing (self-)reflection and evaluation in order to repeatedly challenge the research process-

es, adapt to new conditions, and spark innovations. Real-world labs are therefore education settings for transformatively oriented, transdisciplinary sustainability research. They thus broaden the previous customary focus of TDR processes, which is mainly on integrating and synthesising knowledge for potential application.

Futures studies: a related research area

Futures studies aims at creating orientational knowledge, which is closely linked to target and transformation knowledge (Grunwald, 2014) as well as to the Mode-2 science. Futures studies considers multiple futures, inviting the discussion of

uncertainties and surprises. This also opens up other possibilities of deliberative decision-making for real-world experiments and sustainability decisions (regarding deliberation see, for example, Kowarsch et al., 2016).

The field of futures studies offers several approaches and methods that support transformative sustainability research. First, the generation of target and transformation knowledge can be fostered through both exploratory approaches (e.g. scenario techniques) and normative approaches (e.g. back-casting). Second, approaches that focus on shaping change processes such as, among others, the futures action model (Ramos, 2017) and experiential foresight, can provide, for example, ideas for real-world experiments and interventions that aim to make possible or attain other futures and have strong connections with participative formats and action research. Third, approaches from the area of futures literacy support the training of anticipatory competence, i.e. the ability to conceive of futures as shapable, understand the influence that conceptions of the future have on the present, and actively engage in working with futures.

Transformative competencies for promoting sustainable development

Education for sustainable development (ESD) aims at promoting sustainable development in society while playing a vital role in international programmes and calls for action, the latest being Education for Sustainable Development: Towards Achieving the SDGs (ESD for 2030) (Unesco, 2019).

A main necessary feature of ESD is to equip students with key competencies enabling them to contribute to sustainable development as change agents. In a review of teaching and learning approaches in academic sustainability education, Wiek et al. (2011) identified five key competencies that enable students to understand and shape sustainability and transformation processes. Those are: 1) strategic competence, 2) systems thinking competence, 3) anticipatory competence, 4) normative competence, and 5) interpersonal competence.

The key competencies were instructive in designing the educational components of the Transformative Innovation Lab, presented next.

The Transformative Innovation Lab (TIL)

The format of the Transformative Innovation Lab (TIL) aims to integrate the transformative and transdisciplinary real-world laboratory approach into higher education. The labs operate at the intersection between experimental innovation mode and transformative learning for sustainable development. The objective is to create real-world learning spaces, integrated into existing curricula, which both enable analysis of change processes from a systemic transformation perspective and promote the development of key competencies for their strategic design and implementation through experimentation.

The core of the TIL concept is the integration of theoretical/methodological knowledge, experience, and reflection: in a TIL, students learn about the thematic complexes of sustainability and transformative research and are encouraged to specifically address systems, target, and transformation knowledge in the course of a self-selected project. This is addressed by exploring methodological perspectives of transformative, transdisciplinary, and futures research. Designing and carrying out a (small-scale) mentored transformative research project of their own provides students with an opportunity to apply theory and gain hands-on experience. This give-and-take between theory and practice not only enhances students' learning experience, but also enables them to take a critical view of their own abilities and skills, and of the transformational influence of their own actions.

TIL design and process: transformative research within existing education formats

Rather than developing new educational paths and qualifications, the TIL is designed to integrate transformative research into the learning environment of existing study programmes. Working individually or in small teams, students are mentored at each step of the way by peers and lecturers. The TIL also

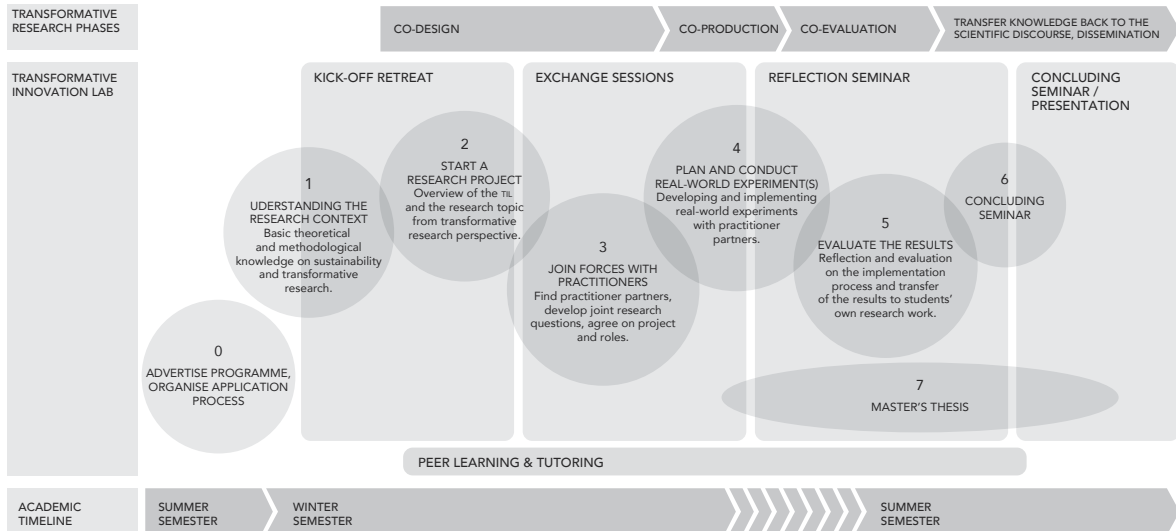
encourages students to use their research project as an experimental master's thesis. The TIL's design and pro-

cess is thus geared to the semester structure and focuses on the real-world lab research phases (see Fig. 2).

Figure 2

Integrated schematic of an ideal-typical TIL.

The individual phases of the TIL are shown in the coloured circles at the centre. In the grey-coloured background, the event formats are shown as they are deployed over the course of the project. With regard to methodology, the transformative research phases are outlined in the upper bar, while the lower bar shows the chronological sequence, broken down by parts of the academic year.



Adapted from: "Transformative Innovation Lab: Handbook to Facilitate Students' Real-World Laboratory Projects to Promote Transformative and Transdisciplinary Competencies", by M. Wanner, M. Schmitt, N. Fischer & P. Bernert, 2020, Wuppertal Institute for Climate, Environment and Energy, pp. 34-35

A TIL is designed to take place in the last two semesters of a master's degree programme. The duration of a TIL can be adapted, however, to students' prior knowledge, any existing research involvement, and, in particular, the complexity of the envisaged projects and whether they are intended for use in a master's thesis.

In the first semester of the TIL, the focus lies on teaching theoretical, and methodological basic knowledge, with students starting a research project and, in parallel, co-designing it together with practitioners. Depending on the study programme and examination requirements, interim results during this phase can take the form of a project report, a portfolio or an exposé for a master's thesis. In the second semester, the main focus is on implementation (co-production) and co-evaluation, for example as part of a master's thesis. At the end of the second semester, students round off the TIL by completing their project assignment.

TIL formats: giving change agents the skills and abilities they need

By conducting real-world experiments in collaboration with practitioners, students contribute directly to the initiation of change processes in society and promote the experimental operationalisation of knowledge on sustainable development in a practical, hands-on way. Rather than perceiving them as competitors, stakeholders often see students as challenging, dynamic actors (Larsson & Holmberg, 2018). This enables a sphere of trust to be built, paving the way for sustainability innovation.

A TIL entails various formats to combine 1) reflection on individual abilities, motivation, and emotions with 2) the acquisition of the methodological and theoretical knowledge needed to carry out a research project and 3) the scope for implementation and experimentation. The chosen formats offer part-virtual, part-real-world settings and a fruitful interplay between the synchronous and

asynchronous phases of the teaching and learning process. This happens in a mix of inputs (from educators and guest practitioners), excursions (e.g. visits to current real-world labs), time for students' own projects, guided exercises, reflection sessions, and experience reports from students. Group elements play an important role in creating a trusted space in which to experiment, reflect and learn, foster exchange, and, where appropriate, form teams to work on research projects.

Key components of the Transformative Innovation Lab (TIL)

- A kick-off retreat over several days at a non-university learning venue marks the beginning of the journey.
- Over the course of the TIL programme, exchange sessions are held on topics matched to where the students are in the process, both as in-person events and as online formats.
- The reflection seminar at the transition from design to implementation is aimed at presenting the individual learning process on the way to becoming a sustainability change agent and critically questioning that process.
- The concluding seminar marks the completion of the TIL programme with the graduates (publicly) presenting their research projects, ideally with their practitioner partners, and a joint celebration. This also provides an opportunity for experience-sharing both between TIL cohorts and between pioneer practitioners and policymakers.

In addition to these shared events, students are continuously mentored throughout the TIL programme. Mentoring includes:

- Peer learning. During the kick-off event, students form teams/tandems to support each other in a self-organised way for the duration of the lab and also learn from one another through mutual exchange. Regular exchange and mutual

feedback with the group as a whole is an integral component of the lab and is made possible through the use of online communication channels and messenger apps.

- Regular colloquia provide students with a platform to present topics and progress made in their research projects or master's theses, and to resolve both subject-specific and formal issues.
- In addition, individual tutoring formats are offered during the course of the lab to provide mentoring during research projects and master's theses and foster interdisciplinary exchange. Ideally, such formats are already provided for in the study programme modules into which a TIL is to be integrated.
- Detailed didactic information on how to conduct each step of the TIL with special focus on understanding the research context, learning objectives, and options for academic implementation are given in the TIL handbook (Wanner et al., 2020) which can be downloaded for free. The project homepage offers material lists and further hints.¹

Learnings from piloting the TIL

In order to put the TIL to test, the model was piloted at two German universities in two cohorts between 2018 and 2020. Through this test it was possible to refine the format and come to grips with its challenges. The following is the result of practical experience gained when implementing and completing the TIL. More details on the learnings can be found in the handbook as well.

How can a TIL be integrated into a study programme?

Study programme selection. Suitable study programmes for a TIL should ideally be linked to or already address sustainable development goals and paths and the role that research plays in change processes. A basic repertoire of research methodologies which students can use in their research projects is essential. To grade the master's thesis and exam-

inable components, sufficient basic knowledge of experimental approaches of this type is needed on the part of the educators.

Implementing a TIL in suitable existing study programme modules. Existing modules of a study programme should be reviewed in terms of content, structure, and examination formats to find a suitable space to integrate the TIL. Project-based seminars, hands-on formats, and master's formats can easily be combined with a TIL. The duration of the underlying module should ideally cover two semesters. The TIL can be easily combined with a wide range of examination requirements, especially with presentations, essays, portfolios, (practice) reports, and oral exams. The examination should value the open learning experience and the practical approach. Consequently, written exams are less well-suited.

Start early when planning a TIL. It is advisable to start planning early (at least one-and-a-half semesters in advance) because universities vary greatly in terms of flexibility with regard to formal and informal requirements.

Keeping an eye on semester schedules and semester timetables. With its two semester layout it is important to ensure that the module neither disrupts the ideal-typical lab process nor prevents the study programme from being completed within the standard period of study.

Determine a manageable group size for participation in the TIL. A TIL requires intensive mentoring of students. The recommended maximum of students per teacher is 10 to 15. If a master's thesis is chosen as the final outcome, the group must be smaller.

Find suitable contact partners and collaborators and join various networks. It can make sense to find out who in the dean's office can help in the design of a seminar and a module for the TIL. The examinations office is also an important touch

point with regard to exam regulations. University-based research projects involving practitioners and local stakeholders provide a good infrastructure that should not go unused. In this way, additional resources can be utilised and practical projects can be academically supported and evaluated.

Advertising the TIL programme and its selection process. To recruit interested and motivated students it proved useful to make use of an application process that allows students to submit an (informal) motivation letter. This simplifies lab planning because it enables an assessment to be made of students' interests, their prior knowledge, and their expectations.

Tips and tricks for TIL implementation: take-aways from sessions

Create a common knowledge base. At the beginning of the lab, theoretical inputs on transformative sustainability research and on the ideal-typical course of a real-world lab are essential. Experts, both researchers and practitioners, should be invited. Developing a common understanding of specialist terms and methodologies is time-intensive but important. Excursions serve as sources of inspiration and in gathering project ideas.

Peer learning for more give and take. It is advisable to have peer learning teams form on a voluntary basis and/or to allow team constellations to be changed as part of the process.

Session design: variety and flexibility. It is important to establish a mix of input, self-experience, time for reflection, and also for fun, joint activities and group elements (e.g. warm-ups, self-organised evening events, sports, and meditation sessions). Alternative approaches such as dialogue walks, room for reflection and idea generation should also be accommodated. Games such as *The World's Future²* simulation enable abstract topics to be addressed and help to illustrate them. Action-oriented approaches

such as a project-related fast-forward session assist students in transferring ideal-typical processes to their project work. Speed-talk sessions are an easy way for students to report on their current state of progress.

Understanding roles and research ethics. Reflecting on one's own role(s) in the (transformative) research process and also on the ethical dimensions of one's own (research) activities is essential and requires space. Many participants report that it is difficult to avoid falling into a one-sided service delivery role lacking any personal research interest or the traditional "objective" analysing role or the role of an activist.

Personal development and expectation management. The transformative research process involves stress-inducing challenges in dealing with the various actors involved. High expectations contrast with what interventions are feasible. Realistic goal-setting is key. Students should be encouraged to think smaller rather than bigger so as to help them to cope with uncertainty. A trusting atmosphere within the group helps students share ideas. It was found to be very helpful to provide input and individual exercises on emotional coping techniques.

Discussion and outlook

With this article, we aim to make a useful and effective contribution to embedding the teaching of transdisciplinary and transformative research more firmly in higher education. Achieving the sustainable development goals—while avoiding solutionism, overreach, and quick fixes—calls for reflective and responsible applied research formats. As these are methodologically and ethically demanding in their application, it is all the more important to provide prudent and broad-based mentoring for learning processes.

Like every project, the TIL has been subject to a range of limitations and a number of issues have arisen that need to be addressed in more detail going forward. These include, for example, academically coherent integration of additional study programmes and empirically sound measurement of students' skills development over the course of the TIL. It is also important to analyse the success factors in and the obstacles to researcher-practitioner collaboration and gain a more differentiated view of their differing roles. Also in its infancy is the retrospective assessment of how such real-world labs impact and affect personal development, the scientific debate, and the promotion of sustainable practices. Formats for transdisciplinary and transformative research and teaching must prove their value on all three counts.

REFERENCES

- Bergmann, M., Schöpke, N., Marg, O., Stelzer, F., Lang, D. J., Bossert, M., Gantert, M., Häußler, E., Marquardt, E., Piontek, F. M., Potthast, T., Rhodius, R., Rudolph, M., Ruddat, M., Seebacher, A. & Sußmann, N. (2021). Transdisciplinary Sustainability Research in Real-World Labs: Success Factors and Methods for Change. *Sustainability Science*. Retrieved from <https://doi.org/10.1007/s11625-020-00886-8>
- Berkhout, F., Verbong, G., Wieczorek, A. J., Raven, R., Lebel, L. & Bai, X. (2010). Sustainability Experiments in Asia: Innovations Shaping Alternative Development Pathways? *Environmental Science & Policy*, 13(4), 261-271. Retrieved from <https://doi.org/10.1016/j.envsci.2010.03.010>
- Bulkeley, H., & Castán Broto, V. (2013). Government by Experiment? Global Cities and the Governing of Climate Change. *Transactions of the Institute of British Geographers*, 38(3), 361-375. Retrieved from <https://doi.org/10.1111/j.1475-5661.2012.00535.x>
- Fuenschilling, L., Frantzeskaki, N. & Coenen, L. (2019). Urban Experimentation & Sustainability Transitions. *European Planning Studies*, 27(2), 219-228. Retrieved from <https://doi.org/10.1080/09654313.2018.1532977>
- Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Peter, S. & Trow, M. (1994). *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: Sage.
- Grunwald, A. (2014). Modes of Orientation Provided by Futures Studies: Making Sense of Diversity and Divergence. *European Journal of Futures Research*, 2(1), 30.
- Hirsch Hadorn, G., Bradley, D., Pohl, C., Rist, S. & Wiesmann, U. (2006). Implications of Transdisciplinarity for Sustainability Research. *Ecological Economics*, 60(1), 119-128. Retrieved from <https://doi.org/10.1016/j.ecolecon.2005.12.002>
- Hirsch Hadorn, G., Jäger, J. & Akademien der Wissenschaften Schweiz. (2008). *Handbook of Transdisciplinary Research*. Germany: Springer.

- Kowarsch, M., Garard, J., Rioussset, P., Lenzi, D., Dorsch, M. J., Knopf, B., Harrs, J.-A. & Edenhofer, O. (2016). Scientific Assessments to Facilitate Deliberative Policy Learning. *Palgrave Communications*, 2(1). Retrieved from <https://doi.org/10.1057/palcomms.2016.92>
- Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M. & Thomas, C. J. (2012). Transdisciplinary Research in Sustainability Science: Practice, Principles, and Challenges. *Sustainability Science*, 7(S1), 25-43. Retrieved from <https://doi.org/10.1007/s11625-011-0149-x>
- Larsson, J. & Holmberg, J. (2018). Learning While Creating Value for Sustainability Transitions: The Case of Challenge Lab at Chalmers University of Technology. *Journal of Cleaner Production*, 172, 4411-4420. Retrieved from <https://doi.org/10.1016/j.jclepro.2017.03.072>
- Leicht, A., Heiss, J., Byun, W. J., & Unesco. (2018). *Issues and Trends in Education for Sustainable Development*. Unesco. Retrieved from <https://unesdoc.unesco.org/ark:/48223/pf0000261445>
- Nevens, F., Frantzeskaki, N., Gorissen, L. & Loorbach, D. (2013). Urban Transition Labs: Co-Creating Transformative Action for Sustainable Cities. *Journal of Cleaner Production*, 50, 111-122. Retrieved from <https://doi.org/10.1016/j.jclepro.2012.12.001>
- Nowotny, H., Scott, P. & Gibbons, M. (2001). *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*. Cambridge: Polity Press.
- Ramos, J. (2017). Linking Foresight and Action: Toward a Futures Action Research. In *The Palgrave International Handbook of Action Research* (S. 823-842). Germany: Springer.
- Schäpke, N., Stelzer, F., Caniglia, G., Bergmann, M., Wanner, M., Singer-Brodowski, M., Loorbach, D., Olsson, P., Bae-deker, C. & Lang, D. J. (2018). Jointly Experimenting for Transformation? Shaping Real-World Laboratories by Comparing Them. *Gaia. Ecological Perspectives for Science and Society*, 27(S1), 85-96. Retrieved from <https://doi.org/10.14512/gaia.27.S1.16>
- Schneidewind, U., Singer-Brodowski, M., Augenstein, K. & Stelzer, F. (2016). *Pledge for a Transformative Science: A Conceptual Framework*. Germany: Wuppertal Papers. Retrieved from <http://nbn-resolving.de/urn:nbn:de:bsz:wup4-opus-64142>
- Scholz, R. W. & Steiner, G. (2015). The Real Type and Ideal Type of Transdisciplinary Processes: Part I - Theoretical Foundations. *Sustainability Science*, 10(4), 527-544. Retrieved from <https://doi.org/10.1007/s11625-015-0326-4>
- Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. & Ludwig, C. (2015). The Trajectory of the Anthropocene: The Great Acceleration. *The Anthropocene Review*, 2(1), 81-98. Retrieved from <https://doi.org/10.1177/205301961456-4785>
- Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., Biggs, R., Carpenter, S. R., Vries, W. de, Wit, C. A. de, Folke, C., Gerten, D., Heinke, J., Mace, G. M., Persson, L. M., Ramanathan, V., Reyers, B. & Sörlin, S. (2015). Planetary Boundaries: Guiding Human Development on a Changing Planet. *Science*, 347(6223). Retrieved from <https://doi.org/10.1126/science.1259855>
- Thompson Klein, J. (2004). Prospects for Transdisciplinarity. *Futures*, 36(4), 515-526. Retrieved from <https://doi.org/10.1016/j.futures.2003.10.007>
- Unesco - United Nations Educational, Scientific and Cultural Organization. (2019). *Framework for the Implementation of Education for Sustainable Development (ESD) Beyond 2019* (S. 19). Retrieved from <https://www.bne-portal.de/files/40%20C%2023%20ESD.pdf>
- United Nations (UN). (2015a). *Nagoya Declaration in Higher Education for Sustainable Development*. Retrieved from <https://sustainabledevelopment.un.org/content/documents/5864Declaration%20-%20Higher%20Education%20for%20Sustainable%20Development%20Nagoya%202014.pdf>
- United Nations (UN). (2015b). *Resolution Adopted by the General Assembly on 25 September 2015 (A/RES/70/1; Transforming Our World: The 2030 Agenda for Sustainable Development)*. United Nations. Retrieved from <https://undocs.org/en/A/RES/70/1>
- United Nations (UN). (2015c). *The Millennium Development Goals Report 2015*. United Nations. Retrieved from [https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20\(July%201\).pdf](https://www.un.org/millenniumgoals/2015_MDG_Report/pdf/MDG%202015%20rev%20(July%201).pdf)
- Wanner, M., Hilger, A., Westerkowski, J., Rose, M., Stelzer, F. & Schäpke, N. (2018). Towards a Cyclical Concept of Real-world Laboratories: A Transdisciplinary Research Practice for Sustainability Transitions. *disP - The Planning Review*, 54(2), 94-114. Retrieved from <https://doi.org/10.1080/02513625.2018.1487651>
- Wanner, M., Schmitt, M., Fischer, N. & Bernert, P. (2020). *Transformative Innovation Lab: Handbook to Facilitate Students' Real-World Laboratory Projects to Promote Transformative and Transdisciplinary Competencies*. Germany: Wuppertal Institute for Climate, Environment and Energy. Retrieved from <https://epub.wupperinst.org/frontdoor/index/index/docId/7685>
- WBGU-German Advisory Council on Global Change. (2011). *World in Transition – A Social Contract for Sustainability*. Wissenschaftlicher Beirat der Bundesregierung Globale Umweltveränderungen. Retrieved from <https://www.wbgu.de/en/publications/publication/world-in-transition-a-social-contract-for-sustainability>
- Wiek, A., Withycombe, L. & Redman, C. L. (2011). Key Competencies in Sustainability: A Reference Framework for Academic Program Development. *Sustainability science*, 6(2), 203-218.

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¹ <https://transformative-innovation-lab.de/en>

² <https://worldsfuture.socialsimulations.org/>