Embracing the Rhizome: Transdisciplinary Learning for Innovative Problem Solving

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Trampoline House in Copenhagen, a hub that assists migrants and asylum seekers by providing shelter within the Danish asylum system, recently adopted the metaphor of a castle to describe its work and conditions: *Kassel Castle*, physically marked by a simple chalk circle at the international art exhibition *documenta fifteen*, was an impenetrable prison, a chain of invisible shackles and intangible politics. Inside, however, there was a hive of activity: in a theater workshop, rejected asylum seekers and young refugees penned skits about their personal experiences with the migration regime. The contestants also served as models for a fashion show by designer Dady de Maximo Mwicira-Mitali. A massage workshop led by and involving displaced people serviced the seemingly utopian practice of "massaging" the asylum system – to make it softer, more tranquil, and less stressful. The castle acted as a jail and a bulwark against an oppressive government. The guiding principles of a creative production of knowledge and practice of mutual learning became justice and freedom.

Trampoline House's artworks are featured on the endpapers of our book, not for aesthetic reasons, but rather to honor their subversive concept: Knowledge created through the arts influences society and serves as an example of the transformative power of transdisciplinary education (Kaiza 2022, 205; documenta fifteen 2022) – and in doing so, it is beneficial for sciences and educational systems as a whole. With techniques that cross traditional disciplinary lines and incorporate information from several fields, learners are given the ability to engage in critical thought and creative problem-solving.

The artistic attempt to produce knowledge resources beyond, against, and across disciplines coincides with another development: Science journalist Max Kozlov (2023) recently revealed that the number of scientific and technological research papers published has increased significantly over the past few decades. However, the disruptiveness of these papers, their impact on the status quo, has decreased, as measured by the degree to which they deviate from previous research. Recent research is less likely to cause major upheaval compared to research conducted at the end of the 20th century. Such an observation raises ques-

tions about the current state of academic research and its capacity to generate innovative solutions and acknowledge responsibility. In pursuit of novel insights and transformative knowledge, it also highlights the need for a transdisciplinary approach that challenges conventional wisdom, integrates diverse perspectives, and pushes the boundaries of established disciplines.

The purpose of this Handbook is to address this need by advocating for and demonstrating the potential of transdisciplinary learning in higher education, thereby fostering an environment that encourages the production of disruptive and transformative research. It aims to introduce transdisciplinary learning with a focus on the fundamental values of liberty and justice. By providing guidelines and strategies for implementing this educational approach, the Handbook seeks to contribute to an education culture in which both students and researchers contribute meaningfully to addressing the pressing global challenges of the present day. Transdisciplinary learning emerges as a promising means for enhancing innovation and transformative knowledge in the context of academic research's diminishing disruptiveness. It offers the potential to revitalize academia and address complex, real-world problems requiring a multifaceted approach by transcending the limitations of traditional disciplines and integrating a variety of perspectives.

Transdisciplinary learning presupposes a systemic change in various ways, particularly in basic teaching attitudes and understanding of didactics. Teachers must be willing to (1) reduce their control if they want to allow a free (inter)play of creative forces. Transdisciplinary work requires a commitment to (2) activate participation and co-creation on the threshold. As a consequence of acknowledging the plurality of knowledge paths, it is essential to (3) embrace failures, setbacks, and detours of students, learners, and teachers. Transdisciplinary practices will also change given structures in universities and contribute to (4) dismantling hierarchies and extending collective responsibility. (5) Reflective practices must be established, respected, and defended. Finally, given the plurality of actors involved, transdisciplinary practices require sound and systematic (6) feedback literacy to ensure that lessons are learned from cooperation with the practical sphere and adequate measures are taken to meet future educational challenges.

With this predisposition, our Handbook enhances a search process that was already gaining momentum, when modern life and cognition models were increasingly criticized. Gilles Deleuze and Félix Guattari, both disturbed by all attempts to dismember and categorize the world by linear and dichotomous patterns, identified the mental figure of the tree that blocked all access to the real world. The tree is a "taproot, with its pivotal spine and surrounding leaves" (Deleuze and Guattari 2013, 3), an organizational model of the trunk and secondary branches, of supporting order and derivatives, of dichotomous, structured categories and subordinate hierarchical ramifications, was debunked as an epistemic model of increasing fragmentation, hybridization, and volatility: "We're tired of trees.

We should stop believing in trees, roots, and radicles. They've made us suffer too much. All of arborescent culture is founded on them, from biology to linguistics" (Deleuze and Guattari 2013, 15). For Deleuze and Guattari, the tree had to be replaced by the "tufted root", a system of small, branching braids whose inconspicuous nodes form non-hierarchical nexuses to each other and are not subject to any categorical or binary order: "Nothing is beautiful or loving or political aside from underground stems and aerial roots, adventitious growths, and rhizomes. Amsterdam, a city entirely without roots, a rhizome-city with its stem-canals, where utility connects with the greatest folly in relation to a commercial war machine." (Deleuze and Guattari 2013, 15)

Thinking in contexts and networks, along with the utopian ideal of the rhizomatic city of Amsterdam, whose stylized canal plan illustrates the cover of our Handbook, have far-reaching implications. Science is no longer a hierarchical, dichotomous, or tree-like order to distribute and stabilize privileges, power, and status. It is rather a cooperative-egalitarian network-based process in which a variety of knowledge resources, educational biographies, and knowledge potentials gain their form. Seen from this perspective, ▸transdisciplinarity (*Vilsmaier, Merçon, and Meyer*) is not a unidirectional integration of "non-disciplinary" or "non-scientific" knowledge into research and learning. Terms of negation, which aim at denying eligibility and qualification, are unsuitable for this discourse. Rather, it is about research alliances of diverse but equal actors and about overcoming the rifts between university and society. ▸Learning in transformation (*Jahnke and Wildt*), ▸experimentation (*West, Böttger, and Tang*), and working responsibly toward ▸global citizenship (*Grobbauer and Whalen*) are defining syntagms of change.

The distinctive *plural* nature of transdisciplinary education equips students with the framework required to differentiate between diverse knowledge-based resources, evaluate their applicability to specific challenges, and devise strategies for integrating these diverse sources into their academic pursuits and research. ▸boundary work (*Vilsmaier and Thompson Klein*), originally coined for analytical purposes to address the problem of *differences*, has been adapted for boundary-crossing and boundary-spanning research to support collaboration in heterogeneous teams. It is not only about the particular characteristics of knowledge fields, but about the participants' specific features, their ability to elaborate on different objectives, roles, and tasks in collaborative processes. ▸Critical thinking (*Barth and Pfister*) is one of the most central skills in transformational dynamics. Though its roots lie in philosophy, it has significant metacognitive features, including the use of techniques for overcoming cognitive biases and navigating a variety of knowledge sources.

Whereas ▸interdisciplinarity (*Thompson Klein and Philipp*) employs a variety of disciplines to tackle a specific issue, but still holds them constrained within disciplinary boundaries, transdisciplinary learning transcends the boundaries of tradi-

tional disciplines and promotes the integration of knowledge from multiple fields such as practical or bodily experiences. This holistic approach to education fosters students' critical and creative thinking, allowing them to apply their skills and knowledge in real-world contexts (Bammer 2015). Transdisciplinary learning acknowledges the multifaceted nature of action and problems, which frequently exist independently, without any mutual relation. The current era necessitates integrative approaches that unite disparate elements to create holistic solutions (Stokols et al. 2008). However, it remains challenging to capture the essence of transdisciplinary learning within the confines of existing disciplines in higher education, highlighting the need for continued research and development of new educational paradigms (Klein 2010).

Transdisciplinary learning promotes a "new production of knowledge" (Gibbons et al. 1994) by promoting experimental and transformative research designs. It actively seeks to integrate a vast array of knowledge resources, such as professional, everyday, and implicit knowledge from various sectors, including politics, civil society, business, and culture (Nowotny et al. 2001). By doing so, transdisciplinary learning calls for a science system that operates in ▸Mode 2 (*Langemeyer and Zimpelmann*). The distinction between two modes of knowledge production sparked an international discussion in the 1990s that focused its attention on the application of research and science in modern society. With this shift, the institutionally protected sphere of research and teaching, known as *Mode 1* and established at universities and colleges, eroded. Knowledge became usable for concrete, problem-oriented solution of social challenges – often in cooperation with new partners from the societal sphere. The new production of knowledge addresses knowledge resources that are cultivated in unexpected and conflictive spheres, as the discussions around ▸indigenous knowledge (*Le Hunte, Yunkaporta, Melvold, Potts, Ross, and Allen*), ▸embodied learning (*Allen, Pratt, Le Hunte, Melvold, Doran, Kligyte, and Ross*), and ▸performative knowledge (*van den Berg and Schmidt-Wulffen*) show. By encouraging collaboration and inclusiveness, this type of learning advances the cause of justice, as it ensures that diverse perspectives are acknowledged and valued in the pursuit of knowledge.

Attempts to achieve participative learning encompass collective practices such as ▸citizen science (*Jaeger-Erben, Becker, Prūse, Mendoza, Gutberlet, and Rodrigues*), do-it-yourself cultures, and ▸fab labs (*Brandenburger, Adzaho, Mostert-van der Sar, Voigt, and Troxler*). ▸Cooperative education (*Coones, Johannsen, and Philipp*), a particular form of transdisciplinary learning, combines academic coursework with practical work experience, enabling students to apply their knowledge in business and administration settings. In fact, most study programs in higher education today provide opportunities to integrate practical experience, often in the professional field students strive for: ▸internships (*Terhart and Weyland*). Yet they are frequently not recognized as a valuable method of transdisciplinary learning, and educational quality can only be achieved if there is a mutual connection between the learning

experiences in the classroom and in the practical field. The preparation before, the support during, and the reflection after an internship ensure a qualitative integration of diverse knowledge into students' academic learning journey.

The educational approach that supports the premise of transdisciplinarity encourages learners to discover solutions unrestricted by conventional wisdom in a freed setting. This way of ▸transformative learning (*Taimur and Ross*) enables learners to reflect on their experiences, beliefs, and assumptions, resulting in profound and long-lasting shifts in their perspectives and actions. The heterogeneity of actors involved, however, requires additional skills in managing the plurality: ▸Feedback literacy (*Schluer, Rütti-Joy, and Unger*), with its high relevance for all areas of life, has long since been addressed by numerous disciplines. Nonetheless, feedback is still frequently thought of in the context of education as a one-way information flow from teacher to student. The modern, socio-constructivist paradigm, in contrast, emphasizes the shared obligations of all participants in the feedback process. Feedback is therefore viewed as a dialogic exchange that is influenced by personal, interpersonal, and environmental aspects. Learners must have the attitudes and skills necessary to seek out, comprehend, and apply feedback to their learning in order to take part in these exchanges.

The digital world and its currencies are likewise impacted by the necessary growth of competencies: ▸data literacy (*Unger, Beck, and Husfeldt*) encompasses the various knowledge components required for sensitive handling of data or decisions made on the basis of data, and it enables students to collect, process, evaluate, and apply data thoughtfully. On the other hand, ▸storytelling (*Cortes Arevalo, Adamson, Fantini, Verbrugge, and Postma*) ensures the pivotal capability of human problem-solving: describing experiences or expressing ideas through language and images supports transformative co-creative learning by tapping into personal and experiential knowledge. Transdisciplinary learning, in addition, can be implemented as a form of ▸research-based education (*Koltay and Karvalics*) that integrates research activities into the learning process. ▸Participatory action research (*Alatorre Frenk, Hensler, and Merçon*), a collaborative approach to research that incorporates stakeholders in the research process, promotes co-learning and empowerment. Instead of conforming to dichotomous, tree-like structures that distribute and stabilize privileges, authority, hierarchies, and status, transdisciplinary learning promotes a collaborative environment that supports a plurality of knowledge resources, educational biographies, and knowledge potentials (Nowotny et al. 2003).

It is not surprising that the main topic of today's debates is societal transformation, as transdisciplinary learning is fundamentally about societal change for a fair future for all. The educational goal ties transdisciplinary learning to ▸education for sustainable development (*Brennan and Sabogal-Paz*) to empower people and communities with the knowledge, abilities, and attitudes required to contribute to a livable future. This emphasis highlights an additional key issue that is some-

times overlooked: societal development cannot occur without the transformation of people's values, beliefs, worldviews, and corresponding inner traits and capacities. The objective is to promote students' knowledge of their underlying motivations and highlight their ▸personal sustainability (*Parodi, Wamsler, and Dusseldorp*). Inevitably, learning is no longer a solitary or private activity: ▸engaged learning (*Chmelka, Griffith, and Weiner*), a term that emerged from service learning, is today a general postulate to encompass pedagogical strategies and to allow students to gain knowledge through meaningful community engagement. From this angle, students are both engaged citizens and, at the same time – far from the logics of the capitalist market and its exploitation goals – ▸entrepreneurs (*Mittelstädt, Mykolenko, and Wiepcke*). Therefore, the educational objective across all subject areas, not just economics, may be to promote entrepreneurial action, spirit, or behavior.

As a distinct approach within the realm of higher education, transdisciplinary learning emphasizes the significance of successful communication between the academic community and various societal sectors, including politics, civil society, culture, and business. Through the involvement of a broad variety of stakeholders, ▸science communication (*Kiprijanov and Joubert*) as a dialogue-focused and participation-oriented activity, plays a crucial part in the exchange of knowledge and research. A wide range of techniques has been established by higher education and research institutions throughout the world as well as other training providers in order to foster the knowledge and abilities required for planning and implementing open discussion and participatory scientific communication.

In a time when knowledge production increasingly transgresses national boundaries, ▸knowledge transfer (*Alhassan and Ruser*) is a practical issue of paramount significance, although the very concept is contested within academic environments of research, teaching, and learning. Substantial learning opportunities in terms of transdisciplinarity can further be explored in ▸Living labs (*Backhaus, Böschen, John, Altepost, Cloppenburg, Fahy, Gäckle, Gries, Heckwolf, Matschoss, Meyer, Münderlein, Schmitt, Sonntag, Timpe, and Gramelsberger*) and ▸real-world labs (*Parodi, Steglich, and Bylund*): integrated research and innovation processes between university and local stakeholders in a public-private-people partnership. Research no longer takes place in closed labs: society itself is the new "laboratory" (Krohn 1994) to develop sustainable solutions. Although the research on these practices has grown in importance over recent years, the involvement of students often remains poor. Most labs are research rather than education oriented. The task is to open the lab culture as a learning arena for students.

The plentiful practical experiences and a lack of reflection on its educational dimension also characterize ▸science shops (*Legris and Becker*), institutionalized by several European universities during the 1980s. Their central goal is to provide participatory research support in response to industry or civil society concerns, particularly with regard to environmental conflicts, urban development, consump-

tion, or sustainable innovation. However, here again, their ability to contribute to transdisciplinary education depends on their degree of student involvement. A similar reform phenomenon, ▸student-organized teaching (*Bönisch, Becker, Blömer, Raj Pandey, Prūse, and Vollbehr*) offers a major opportunity to experience transdisciplinarity individually on any chosen topics. The idea is easy: Any student can set up a project workshop with other colleagues or stakeholders. This approach permits studying without any professors or research assistants, with guidance provided only by a student tutor.

The panorama of transdisciplinary learning is even broader than these institutionalized programs and also covers uncountable creative practices. Typically, ▸scrum (*Heibges, Jungnickel, and Feufel*) can be used as an agile, playful project management framework that emphasizes iterative progress, collaboration, and adaptability in order to efficiently achieve project goals. ▸Design thinking (*Taimur, Peukert, and Pearce*) is also frequently employed as it emphasizes empathy, experimentation, and iteration to create solutions. ▸Hackathons and challenge-based learning (*Massari, Roversi, Finn, Solimeo, Jatwani, Fusco, Solimeno, Cavicchi and Vignoli*), short-term events, in which obstacles must be overcome in a collective, often tech-based strategy, are an increasingly popular way to bridge the gap between academic research and practical applications. Transdisciplinary potential can also be attributed to ▸case studies (*Meyer, Brundiers, Mader, and Weiser*): they aim at helping students to find a better understanding of identified problems, by investigating their origins, extent, and dynamics in the specific context and by deriving transferable knowledge for similar and future problems.

Transdisciplinary action, by all these practices, takes place in a "Third Space" (Soja 2007) where practitioners, educators, curriculum developers, and other stakeholders work together to create learning scenarios. It is closely related to learner-centered, research-driven teaching strategies that adhere to constructivist principles, prioritize active learning, and support the growth of higher-order thinking skills – strategies aim to produce ▸scientific knowledge (*Walter and Kremer*) by methodically observing, testing, and analyzing social phenomena. Transdisciplinary research may be open to accusations of solutionism or to being branded as tendentious commissioned research due to its emphasis on quick, usable solutions to problems. Thus, in order to conduct and report this particular form of research in accordance with ethical principles and professional scientific standards, it requires its own reflection and discourse within the framework of ▸research integrity (*Alavi and Schmohl*).

Transdisciplinary learning, as our overview shows, involves a focus on practical challenges, knowledge integration, normative components, and collaboration among many stakeholders. Although transdisciplinary learning does not create a new field, it enriches existing ones. In conclusion, the contributions to this Handbook underline the importance of higher education as an environment for the

personal development of both students and instructors. The primary objective of academic education is not preparation for the labor market, but the participants' personal development. The promise of comprehensive education applies to everyone. Universities are not neutral spaces, but rather sites of contentious debate. With its ability to house the rhizomatic diversity of knowledge resources, it serves as an agonistic arena (Mouffe 2013) of the various forms of cooperation that societies create in response to complex problems. By encouraging a collaborative and equitable transdisciplinary approach to learning, this Handbook is a contribution to setting the stage for conflict, passion, and difference across, beyond, and away from disciplines.

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