



Enablers of transdisciplinary collaboration for researchers working on climate risks in African cities

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Abstract

This study explores enablers that help researchers to undertake collaborative transdisciplinary work with non-academic actors to co-produce knowledge on complex climate risks in African cities. Enablers were explored using a qualitative case study approach and expansive learning theory, which emphasises the embeddedness of practices in cultural and historical contexts. Concepts associated with expansive learning helped to consider relational enablers, namely: (i) capabilities required by researchers to understand the perspectives, values and motives of non-academic actors and make their own explicit; (ii) characteristics of spaces that allowed diverse participants to engage with perspectives, values and motives of others; and (iii) knowledge of the motivation behind different practices of non-academic actors, as embedded in different contexts. Findings highlight the importance of researchers' intentional efforts to engage non-academic actors in their city contexts and respond to local priorities. Design elements that enabled relational work included explicit co-production framings, sharing experiences and opportunities for understanding various actor groups through structured activities and informal dialogues. The study highlights the situated and dialectical relationship between growing relational capabilities of researchers and their engagement in transdisciplinarity, provided spaces were created for reflection on activities. Relational enablers helped researchers to understand the heterogeneous experiences of actors working in African cities and tensions that influence their practices including traditional knowledge paradigms and siloed ways of working. The “champions” identified by researchers were those non-academic actors who took agency to engage with these tensions and begin transforming their practices towards multi-actor transdisciplinary knowledge co-production.

Keywords Transdisciplinary learning · Relational enablers · Common knowledge

Introduction

Transdisciplinarity is a relational epistemology that allows researchers to work with non-academic actors to problematize complex challenges and consider contextual responses (Cundill et al. 2019; Mitchell et al. 2015; van Breda et al. 2016). While several studies report on transdisciplinary approaches and methods in African cities (e.g., see case studies in Hemström et al. 2021; Patel et al. 2022; Thondhlana et al. 2021), there is a need to further theorise enablers

of transdisciplinary collaboration in these contexts. This paper deploys concepts associated with expansive learning theory to explore enablers for researchers to undertake collaborative transdisciplinary work with non-academic actors to co-produce knowledge on climate risks in African cities.

Experiences of climate risks in African cities are influenced by particular dynamics of urbanisation (e.g., informality) (Cobbinah and Finn 2022). While climate hazards might be similar across large areas, urban climate risks are driven by many complex non-climatic drivers, which differ across heterogeneous landscapes and evolve with patterns of rapid urbanisation (Dodman et al. 2022; Grimm et al. 2008; Taylor et al. 2021a). Locally led, collaborative and context-driven responses to these risks are critical (Cobbinah and Finn 2022).

With the idea of transformation of culture at its core, the theory of expansive learning helps to understand how people practise transformative agency to adopt collaborative

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and novel practices to respond to complex, pervasive problems, which manifest extremely differently across local contexts (Engeström and Sannino 2010; Yamazumi 2020). McClure et al. (2023) report on transdisciplinary learning processes that allowed multiple actor groups, including academic and non-academic actors, to collaboratively grapple with contextual climate-related risks in Lusaka (Zambia), brainstorm locally relevant means to overcome these and practise agency towards implementing responses, indicating expansive learning.

Expansive learning emphasises the embeddedness of practices (e.g., research or policy) in cultural and historical contexts, and the efforts required to work collaboratively across these practices to respond to complex problems (Engeström and Sannino 2021). Scholars theorising the collaborations between actor groups involved in expansive learning argue that capabilities are required to work in “sites of intersecting practices” to bring different perspectives to bear on complex problems and to collectively strategize responses to these problems (Edwards 2011, p. 2). This study aims to better understand the capabilities required by researchers and the characteristics of ‘sites of intersecting practices’ that enable collaboration with non-academic actors in African cities during transdisciplinarity, particularly to co-produce knowledge relevant to African urban climate risks. The concept of enablers is used broadly to refer to these two dimensions, which are both important considering the dialectical and situated nature of expansive learning.

A qualitative case study approach was employed, focusing on researchers who participated in the transdisciplinary Future Resilience of African CiTies and Lands (FRACTAL) project. FRACTAL aimed to bring together scientists with representatives from government, NGOs and civil society organisations in nine southern African cities to co-produce knowledge with the overarching aim of supporting resilient urban development (www.fractal.org.za). FRACTAL was designed to be explicitly transdisciplinary to enable collaborative exploration of challenges in southern African cities in relation to a changing climate and to support the integration of climate knowledge into decision processes.

The study begins by summarising the theory of enablers of transdisciplinarity that facilitate collaborative work, and providing a rationale for how expansive learning can enrich this theory. Thereafter, the qualitative case study methodology that was employed to analyse such enablers in FRACTAL is described. The FRACTAL case study is presented in the methodology section. The results from the analysis are shared and discussed in the context of the growing body of knowledge on enablers of transdisciplinary collaboration, and with an expansive learning perspective. The study ends with a conclusion that highlights the findings and illustrates their significance.

Enablers of transdisciplinary collaboration

Transdisciplinarity responds to the limitations of traditional research-for-policy approaches by rooting responses in action, drawing on insights across disciplines and inviting non-academic actors as equals into processes of co-producing knowledge (Hirsch Hadorn et al. 2008; Mitchell et al. 2015). Transdisciplinary participants co-construct an understanding of a problem, moving away from the idea that problems exist ‘out there’ to be discovered by specialist science (Klein 2018). Proponents of transdisciplinarity emphasise the dialectical and dynamic relationship between different groups of people, their knowledge and their material and social worlds (Cockburn et al. 2020; Klein 2018). Transdisciplinarity is therefore a relational epistemology that “accentuates interrelationships in collective efforts to integrate knowledge and expertise in a process-based co-construction of knowledge within dialogical spaces and cultures” (Klein et al. 2018, p. 21).

By inviting diverse actors to participate in learning processes, transdisciplinarity is an explicitly social process that enables creation of knowledge relevant to a particular social, cultural and material context (Cockburn and Cundill 2018; Klein 2018; Lang et al. 2012; Scholz and Steiner 2015). Emergence is a key characteristic of transdisciplinarity as ideas and perspectives of participants are “amplified by interactions” with others in the context of a common problem (Klein 2018, p. 18). Learning processes and outcomes can consequently diverge from initial expectations for transdisciplinarity (Cundill et al. 2019). A “dialogical space” in which different actors can engage is critical for working with such tensions and co-constructing knowledge (Decuyper et al. 2010, p. 117).

As a relational epistemology, transdisciplinarity requires extraordinary participation and collaborative learning between a diversity of actors (Cockburn et al. 2020; Craps 2019; Fam et al. 2016; Klein 2013, 2018; Pohl 2011). The vast differences between participating actors means that special efforts need to be directed at collaboration (Klein 2018). This aligns with the efforts that have been described in urban planning and development literature to explore ‘conflicting rationalities’ associated with African urbanisation, and assumptions that might be made by actors involved in collaborations (Smit et al. 2021; Watson 2014). These rationalities, which relate to key concepts and issues between different actors but also geographies, are driven by ideological, education, contextual and personal factors (Smit et al. 2021; Watson 2014). Within transdisciplinary literature, efforts directed at collaboration have been reported on, to some extent, within three broad dimensions: capabilities of individuals, design considerations of transdisciplinary spaces, as well

as enablers for working relationally while also acknowledging systemic features. These dimensions are described in more detail below.

The capabilities of individuals have been most extensively theorised in literature on enablers of collaborative transdisciplinary work. Several studies have provided insight into the “heterogeneous transdisciplinary individual”, which includes attitudes, cognition, skills, characteristics, traits, virtues, values, behaviours and practices that enable effective transdisciplinary engagements with other actors (Augsburg 2014, p. 233). Reported capabilities include creativity, social awareness, commitment to team research for dealing with complex problems, modest positionality, holistic thinking and the ability to make connections, curiosity, willingness to take intellectual risks, flexibility, reflexivity and critical awareness, good communication and inter-personal skills, appreciating different perspectives, confidence in professional and self-identity, and willingness to share responsibilities (Augsburg 2014; Cundill et al. 2019; Fam et al. 2016; Jacobs and Nienaber 2011; Misra et al. 2015; Nash et al. 2003; Nicolescu 1999; Patel et al. 2022; Wall and Shankar 2008). The growth of capabilities occurs through both structured and experiential learning and is often a dialectical process—these competences are often grown in environments of ongoing collaborative efforts for solving complex problems that allow for reflection on practices (Fam et al. 2016; Hakkarainen et al. 2017; Klein 2018; Riedy et al. 2018).

Design considerations influence the collaborative potential of spaces in which transdisciplinary participants engage (Cundill et al. 2019; Lang et al. 2012). Such considerations include situating transdisciplinary learning processes in the problem context, frequency of face-to-face engagements, availability of resources to support engagements and teamwork, existence of platforms to support work across contexts, continuity of team members, surfacing and dealing with differences across academic and non-academic stakeholders and the iterative extent of engagements (Augsburg 2014; Clarke 2016; Cundill et al. 2019; Patel et al. 2022; Wall and Shankar 2008). Drawing on Stokols et al. (2008), Cundill et al. (2019) also note the influence of the physical environment in which collaborative learning takes place, as well as the organisational, social and political factors that influence participation. Patel et al. (2022, p. 11) note the importance of the “iterative and non-binding” transdisciplinary approach to navigate shifts in African city contexts (e.g., political changes) and support “fluidity of stakeholder identities”.

There is a growing body of knowledge related to the concept of ‘scaffolding’ for growing capabilities of individuals and to facilitate effective transdisciplinary learning (Andersson and Palmer 2023; Barrett et al. 2019; Kemp and Nurius 2015), which aligns with design considerations. Scaffolding is an “integrated, yet dynamic, concept” that relates

to methods, processes, structures and ideas that are put in place, at least initially, to allow participants to exercise relational skills and learn collaboratively (Andersson and Palmer 2023, p. 31). Andersson and Palmer describe approaches, methods and tools that provide scaffolding for collaborative transdisciplinary work. These include platforms that allow for sharing diverse opinions, points of departure and goals across participants to analyse and orient work, careful facilitation that can guide iterative learning, and approaches that allow for navigating uncertainty such as working with commonality, as well as time for experimentation and iteration. Andersson and Palmer (2023) also emphasise the importance of monitoring and evaluating scaffolding approaches, allowing participants to reflect on what they had learnt and to strengthen these approaches.

Cundill et al. (2019) argue that there is a need to look beyond individual capabilities and design features to enable effective transdisciplinary collaborations. These authors call for a stronger focus on relational features that grow during multi-stakeholder engagements and systemic features, which vary across contexts. A focus on relational features requires looking beyond individual participants and the space in which engagements occur, to better understand, mediate and nurture interactions between participants. Importantly, relational features are dynamic, evolve over time and are strongly influenced by systemic features, which occur because of “pre-existing norms and biases” (Cundill et al. 2019, p. 4). Relational features include the existence of relationships, trust and mutual respect, leadership styles and processes to constructively engage with tensions that exist between people and groups (or lack thereof) (Cundill et al. 2019). Systemic features include, e.g., power asymmetries and cultural norms. Efforts are required to overcome misunderstandings, disagreements or inequities that occur because of these features. Examples of such efforts include developing legal partnerships, presence of leadership that acknowledges various institutional values and cultures, as well as the flexibility of funds available for ‘nimble’ responses that can facilitate collaboration (Cundill et al. 2019).

An expansive learning perspective on relational enablers of transdisciplinarity

Process theories of learning can offer useful perspectives on collaborative work. Expansive learning is a process theory of learning that helps to understand the many factors involved in learning and change. These factors are considered holistically by focusing on human activity, which comprises the relations between people involved in learning, their motives and cultural and historical contexts (Engeström 2001). This perspective breaks away from homing in on an individual when understanding learning, and from the dualistic

perspective of considering learners as separate from their environments (Roth and Lee 2007).

Expansive learning centres “inner contradictions” as driving forces of change within and between human activity (Sannino and Engeström 2018). These contradictions are “systemic phenomena” that cannot be “accessed” through empirical studies, but expansive learning offers conceptual tools to study the manifestation of these contradictions as tensions, dilemmas or conflicts (Sannino and Engeström 2018, p. 49). Learners are not considered passive subjects, but take volitional actions to overcome the manifestations of contradictions, and in so doing contribute to redefining themselves, their objective and activities (Engeström 1987; Engeström and Sannino 2010; Sannino and Engeström 2018). As such, learners practise transformative agency to “break away from the given frame of action” and take “initiative to transform” activities (Virkkunen 2006, p. 49). Centring the manifestations of contradictions is therefore key to expansive learning.

From an expansive learning perspective, complex problems such as those associated with climate variability and change are qualitatively different from well-defined issues because they manifest variably across space and time, are constantly evolving and responses to such problems require dynamic, collective efforts (Engeström and Sannino 2010; Yamazumi 2020). Expansive learning scholarship increasingly emphasises the importance of multi-actor collaborations and networks for dealing with complex problems (Yamazumi 2020). Building such collaborations requires particular effort because of the situatedness of people’s motives and practices in their own contexts, and because knowledge and ideas are accrued within these contexts (e.g., research, activism, policy, etc.) (Edwards 2021). Actors must therefore make effort to work with others in “sites of intersecting practices” to identify and overcome tensions within and between practices and expand their activities towards a novel, shared objective to respond to complex problems (Edwards 2011, p. 10).

The concepts of relational expertise, common knowledge and relational agency, which are rooted in expansive learning, help to explain efforts for growing multi-actor collaborations towards a common objective through expansive learning. Subjects practise relational expertise to jointly interpret a problem with actors from other socio-cultural contexts. This involves making effort to understand the perspectives, values and motives of others relative to a common problem and, importantly, making one’s own explicit (Edwards 2017). Edwards (2017, p. 8) notes that these joint activities should allow for the objective to be “collectively expanded to reveal as much of the complexity as possible”. People can potentially collaborate effectively across contexts based on well-established friendships and trust, but these relationships might not be

effective for dealing with the variety of complex problems with which they are faced (Edwards 2017). Those who work at sites of intersecting practices on an ongoing basis therefore need to actively practise expertise that helps to reveal perspectives, values and motives across contexts, and adjust their own practices based on strengths and needs within the collective (Edwards 2017).

By practising relational expertise, common knowledge can be grown, which is a “respectful understanding of different professional motives” and is a resource that mediates responsive collaborations on complex problems (Edwards 2017, p. 9). Importantly, common knowledge is not equated to knowing what others do (i.e., their job description) but is an understanding about what motivates and drives various practices (Edwards 2017). Common knowledge doesn’t arise spontaneously when people spend time together, but it is created when sites of intersecting practices allow for listening to, recognising and engaging with diverse perspectives, values and motives, and identifying similar goals across groups (Edwards 2017). Sites of intersecting practices require careful management to support the development of common knowledge (Edwards 2011). Actors practise relational agency when they use the common knowledge as a resource to jointly take action to respond to a common problem with other actor groups (Edwards 2017).

Since transdisciplinarity is a relational endeavour that relies on the contributions of different types of actors, expansive learning theory has the potential to add new insights to the growing body of knowledge on enablers of collaboration between actors from vastly different cultural, historical and material contexts. Expansive learning can therefore provide a conceptual framing to explore enablers for working across paradigms, disciplines, social contexts (e.g., researchers and non-academic actors) as well as material contexts (e.g., global north and global south cities). The contributions of this theoretical perspective are shown in Table 1.

With an expansive learning perspective, there is an emphasis on exercising capabilities that allow one to better understand the perspectives, values and motives of others relative to a common problem, and make one’s own explicit. Expansive learning also draws attention to the characteristics of ‘sites of intersecting practices’ that help to grow common knowledge. The concept of common knowledge deepens thinking around relational and systemic features by emphasising the need to respectfully understand perspectives, values and motives across actor groups that can be used as a resource to facilitate collaborative work. Expansive learning also helps to conceptualise the strong linkages across the various types of relational enablers. For example, one needs to practise relational expertise to grow common knowledge.

Table 1 Conceptual contributions from CHAT for understanding relational enablers of transdisciplinary collaboration

Relational enabler (transdisciplinary theory)	New perspective added by CHAT
Personal capabilities of transdisciplinary participants	Relational expertise: efforts made by participants to understand the perspectives and motives of others relative to a common problem and make one's own explicit
Design considerations	Considerations in "sites of intersecting practices": the design considerations that allow participants to listen to, recognise and engage with perspectives, values and motives across socio-cultural contexts and to recognise similar goals
Relational and systemic features and characteristics	Common knowledge: an understanding of the motivation behind others' practices, as embedded in socio-cultural contexts

Study aim

The aim of this study was to enrich transdisciplinary theory on enablers for researchers to work collaboratively with non-academic actors in African cities to co-produce knowledge relevant to complex climate risks. Concepts associated with expansive learning, which account for the challenges involved in working across contexts, were deployed to add a new perspective on collaborative transdisciplinary processes (see above). The study follows on from McClure et al. (2023) who reported on steps taken towards expansion during FRACTAL transdisciplinary learning processes in Lusaka (Zambia). It also builds on insights gleaned by Cockburn et al. (2020) who deployed similar relational concepts to explore engagements of actors involved in landscape stewardship in South Africa, and helped to reveal social-relational practices that support boundary crossing work. It also responds to the call from Cundill et al. (2019) to expand and deepen the focus on relational enablers and systemic features involved in transdisciplinarity.

Materials and methods

A qualitative case study approach was employed to explore enablers for researchers participating in the FRACTAL transdisciplinarity project (Ary et al. 2002; Miles and Huberman 1994). The study was designed near the end of FRACTAL (2021), during which a retrospective mixed inductive–deductive approach to reasoning was adopted. The relational concepts associated with expansive learning informed the study design (i.e., to design data generation tools). These concepts were combined with a grounded theory approach to analysis to allow for themes to emerge from the data.

FRACTAL case study

African cities are hotspots of complex climate-related risks (Taylor et al. 2021a). Urban residents are potentially at risk when they experience climate-related hazards alongside development and well-being issues such as inter alia

infrastructure and public service deficits, high rates of unemployment and weak local economies (Kareem et al. 2020; Parnell and Oldfield 2014; Satterthwaite et al. 2018). Many urban residents live in informal settlements, which often increases their exposure to climate-related hazards and/or vulnerability (Finn and Cobbinah 2022). Climate-related risks in cities are expected to worsen in the future (Dodman et al. 2022).

FRACTAL (2016–2021) aimed to increase the understanding of the climate sensitivities of southern African cities under conditions of climate change while acknowledging the strong linkages to scales beyond the city in terms of resources and governance. Considering the complexity associated with climate-related risks in southern African cities, FRACTAL explicitly adopted a transdisciplinary approach, involving researchers from different disciplines across southern Africa, Europe, the UK and the USA States who worked alongside non-academic actors in nine southern African cities. The transdisciplinary framing supported multi-actor engagements through several approaches. While these approaches differed across cities based on research needs that emerged, city learning labs and the embedded researcher approach were seen as core transdisciplinary activities (see Table 2 below).

Learning labs brought together a variety of actors to explore the complexity of each city in terms of patterns of urbanization and its intersection with climate variability and change (up to the year 2040). Founded on the principles of transdisciplinarity, adult learning and knowledge co-production, the learning labs were implemented as spaces in which multiple actor groups could collaboratively interrogate various dimensions of cities relevant to climate risks. While labs' learning processes and outcomes differed across cities, all were context led and began with the collaborative identification of a 'burning issue', which would likely get worse under conditions of climate change. This issue was then explored from different perspectives through transdisciplinary activities. Between 2016 and 2019, five learning labs took place in Lusaka (Zambia), four took place in Windhoek (Namibia) and four in Maputo (Mozambique).

An Embedded Researcher approach was core to FRACTAL (Taylor et al. 2021b). Six early career researchers were

Table 2 Transdisciplinary activities implemented during FRACTAL

City	Activities						
	Learning labs	Embedded research	Co-exploration and co-production dialogues	Co-production of climate risk narratives	Small grants to explore aspects of the ‘burning issue’	‘Think tanks’ to explore values and perspectives	Participation in multi-actor annual meetings
Blantyre	X		X	X	X	X	X
Gaborone			X	X			X
Cape Town		X			X		X
Durban		X		X			X
Harare		X	X	X	X	X	X
Johannesburg							X
Lusaka	X	X	X	X	X	X	X
Maputo	X	X	X	X	X		X
Windhoek	X	X	X	X	X	X	X

contracted to local university partners in FRACTAL cities, but their time was split between these institutions and government organisations. The Embedded Researchers fulfilled a boundary spanning role, particularly in terms of disciplinary, organisational and sectoral boundaries. Taylor et al. (2021b) report on four themes with regard to the important contributions of Embedded Researchers during FRACTAL, namely cultivating trust-based relationships and reciprocity across actor groups, supporting collaborative agenda setting and combining knowledge, promoting reflexivity and innovation, and navigating multiple accountabilities.

FRACTAL resulted in several notable societal impacts, ranging from improved communication between a wide variety of actors in each city (Mamombe et al. 2019), long-term partnership agreements between academic and non-academic organisations particularly through the establishment of Memoranda of Understanding in Gaborone, Harare and Windhoek, mainstreaming of climate change into government planning processes and supporting the development of climate change policy briefs in Lusaka and Harare (Taylor et al. 2021c; Ndebele-Murisa and Mubaya 2019), and an Integrated Climate Change Strategy in Windhoek (Haukelo et al. 2019). Trust was noted many times in FRACTAL as important for nurturing relationships and networks across cities (e.g., see Ndebele-Murisa et al. 2020 and Jack et al. 2020).

Data generation

The study aimed to better understand enablers for researchers participating in FRACTAL to collaborate with non-academic actors during transdisciplinarity. With an expansive learning perspective, these enablers are associated with capabilities exercised by researchers and their experience of the transdisciplinary space (Edwards 2017). A qualitative approach to inquiry was deemed appropriate to generate

data on these aspects (Dowling et al. 2016). Semi-structured interviews enabled insights into the experiences of researchers (Terre Blanche et al. 2006). The concepts of relational expertise, common knowledge and relational agency informed the design of interview instruments.

Purposive sampling was used to identify researchers who had engaged most extensively in transdisciplinary processes throughout FRACTAL, as well as two additional team members who worked closely with these researchers during transdisciplinary planning and engagements (Terre Blanche et al. 2006). It was assumed that this type of sampling would contribute to generating rich data on the experiences of researchers and transdisciplinary spaces (Terre Blanche et al. 2006). Interviewees included a diversity of nationalities, races, genders and disciplinary domains, as well as those working in different geographical locations. In total, 13 face-to-face interviews were undertaken in English, which were recorded using Zoom software (<https://zoom.us>) and transcribed thereafter. All procedures followed were in accordance with the University of Cape Town research ethics code for research involving human participants.

Data analysis

The author analysed the transcripts of interviews using grounded theory as a flexible approach as opposed to a strict methodology, combined with the “theoretical vantage point” provided by expansive learning relational concepts (Seaman 2008, p. 3). This approach allowed for the author to remain open to themes that emerged within the data and receptive to local conditions as described by researchers (Seaman 2008; Saldaña 2013).

Initially, the transcripts were read and broken into the smallest units of meaning according to actions that were implemented by researchers or processes that occurred during the transdisciplinary engagements (i.e., process coding)

(Saldaña 2013). Examples of these units include “extent of participation influencing relationships” and “tailoring engagement for politicians”. The author then used a constant comparative approach to develop a set of mutually exclusive categories ($n = 12$) from these units (Lewis-Beck et al. 2012). Examples of categories are: “attitude”, “strategies employed”, “transdisciplinary activities”, “challenges”, “knowledge of actors” and “knowledge of contexts”. The interviews were then coded again using these categories. Data related to categories were then grouped according to relational concepts associated with expansive learning and compared to understand relations between categories. This helped to flesh out concepts of: (i) capabilities of researchers; (ii) design considerations in sites of intersecting practices; and (iii) common knowledge for undertaking collaborative transdisciplinary work on African urban climate risks.

Results

The results from the analysis are presented below according to three sections, namely: capabilities of researchers, design considerations in sites of intersecting practice and common knowledge for undertaking collaborative transdisciplinary work on African urban climate risks.

Capabilities of researchers

Respondent 6 reported an increasing need to constantly “think things through” and to understand the different lived experiences of participants. This same respondent noted that “blind spots” are enforced when researchers are not exposed to different perspectives, situations and cultures, and are not provided with an opportunity for reflection. Respondent 7 noted the importance of being honest about not knowing, explicitly acknowledging when she learned something new from non-academic actors and “not be[ing] a mystery” to these actors (7). Several respondents learned to be increasingly aware of their biases, blind spots and judgements as a result of engagements, as well as the power dynamics between different groups of people (3, 6, 10, 12).

Respondents 1 and 10 acknowledged the importance of researchers opening up and “letting go”, particularly in terms of how research is envisioned, outcomes are planned and how research outcomes might be effectively communicated (1, 10). This can be challenging as it requires researchers to “leave agendas at the door” (1, 12). Researchers needed to adopt a more “porous” approach, allowing for input by the broader team because inflexible research “closes out opportunit[ies] for others to get involved or to slightly change the course of that piece of work” (1). This porosity required researchers to be more courageous as they invited

interrogation (and in some cases scepticism) of their work (3, 12).

Several respondents suggested that an important role of researchers in FRACTAL was to support critical interrogation across groups of participants, and that such interrogation was often sparked by sharing scientific content (3, 7, 10). Respondents 1 and 5 shaped their role according to gaps that they noted in the transdisciplinary team, while respondents 2 and 10 explicitly shaped their inputs based on gaps noted in the city contexts (e.g., capacity and knowledge gaps). Respondent 1 noted that research interests became clearer during engagement in cities: “Then, my interest out of those labs in the groundwater and Managed Aquifer Recharge Scheme, that really emerged out of the labs” (1). Common across the researchers were values of wanting to support people, a proactive attitude to the work, being actively involved in dialogue and steering away from dominating discussions with academic content (1, 9, 12).

Respondents 3 and 12 commented on an increasing tendency towards the “collective concerns” of the transdisciplinary group, and in some cases this became more important than their own personal research objectives (3, 12). As the transdisciplinary processes unfolded, respondent 3 felt like they became a “part of everything” and became most concerned with the design of an effective transdisciplinary co-production process (3). Respondents understood collective concerns by spending considerable lengths of time with actors in cities, engaging in dialogue and asking questions on a variety of topics, including those outside their expertise (2, 4, 8, 10, 12). Consistently “showing up” as a participant of transdisciplinary processes was important to build relationships (12). Researchers were also required to be attentive, as evidenced by the following quote: “I think listening and asking better questions based on that listening. Not just repeating the same agenda that you have but adapting, maybe even if it doesn’t fit with what you’d planned, so to go in a completely different direction. It’s hard, it takes a lot of courage to do that, and I’m not saying I’m good at doing that at all, but I do think that’s important... hearing what people are saying and responding to it” (10).

Strategies that were intentionally employed by respondents to work relationally in FRACTAL included: seeking out participants during lunch or tea breaks of learning labs and other events to initiate informal dialogue (1), actively starting conversations and showing interest by asking questions of clarity, reading body language and being sensitive to the evolution of the conversation (5, 7, 9) and communicating consistently with stakeholders using a variety of methods including emails, phone calls and office visits (2, 4, 7, 8). Respondent 2 acknowledged the importance of implementing these strategies early to “get off on the right foot” and of inviting all non-academic actors to have a “seat at the table” from the very beginning of the project. Expressing interest

in the perspectives of others and being sensitive to issues that might not be explicitly stated were important for understanding participants, particularly those from very different backgrounds (4, 5, 7, 9, 10).

Prior experiences of respondents influenced their approach to FRACTAL work (7, 10). For example, the “ethnographic” background of a social scientist helped them to more easily participate in context-led work, as evidenced in the following quote: “Because my background is in anthropology and ethnographic approaches, it really is always my approach to go in without assumptions and try to figure out the challenges and decisions that are trying to be made and what’s blocking that... it would be that the environment or climate is in the background but for me it’s not the main driver when I start the conversation” (12). Another natural science respondent noted the benefits of historical working relationships with social scientists, which had helped them to understand the importance of engaging “cautious[ly]” to allow for an understanding of the context to emerge (8). Respondent 3, with a natural science background, reflected on the limitations of their training to learn relational capabilities despite an increasing emphasis on effective science communication.

Respondents 3 and 4 acknowledged the dialectical relationship between valuing working collaboratively with different participants and the FRACTAL transdisciplinary co-production processes, which “interact and shape each other to quite a degree” (4). FRACTAL provided spaces for researchers to reflect on co-production processes, which supported relational growth (4, 6, 10) as evidenced by the following quote: “I do feel like my understanding of the importance of relationships deepened because we actively reflected on it... Being in that space made me reflect more and learn a lot about the dynamics of it and the importance of it” (6). Respondents 1 and 5 reflected on the fact that their relationships with other participants (including researchers) grew “organically” because of the effort that they put into developing these (1, 5).

Design considerations in ‘sites of intersecting practice’

FRACTAL’s transdisciplinary co-production framing gave researchers a mandate to work relationally from the beginning (1). Although the proposal did not explicitly mention relationships, methods that were included in the proposal aimed to support equal participation by a diverse group of people (e.g., learning labs) and to make connections across different social, cultural and material worlds (e.g., embedded researchers) (1, 8, 9, 12). Researcher 1 acknowledged the importance of strong, non-academic personalities at the first FRACTAL team meeting who pushed back on academic framings and helped other

non-academic participants (e.g., municipality representatives) feel “emboldened” to challenge academic framings and terminology. The “philosophy of co-production” was also explicitly emphasised in transdisciplinary engagements in cities, which helped to “break down barriers” between researchers and non-academic actors (2, 9). This philosophy diverged from hierarchies that are associated with traditional academic culture (3).

The diversity of people who were invited to learning labs helped “scale up” previous efforts of researchers to work with non-academic actors to co-produce knowledge (9). The emergence of transdisciplinary processes was important for researchers to hear the concerns and objectives of other participants and implement “course correction” in their own work to respond to these (10; 12). A “permission to fail” ethos was also important for researchers to embrace emergence, complexity and working collaboratively (10, 12). This ethos enabled a more experimental approach, and for researchers to take risks in terms of free-flowing dialogue (10, 12). Rigid projects and strict funders do not usually allow for emergence (10).

Learning labs spanned several days and participants shared “intense experiences” while staying in the same place, i.e., eating meals together, visiting sites across cities and participating in learning activities (1, 6, 9). These labs were experienced by respondents as immersive and much more sustained and iterative compared with conventional workshops (1, 5, 6, 8, 9). Learning labs were intentionally hosted away from physical work environments, which provided distance for participants to “be a bit more of an individual” (3). This physical distance was also important to collaboratively reflect on the challenges experienced in cities and opportunities for responding to these challenges (12). Site visits helped to “build a level of understanding” of various social realities in cities (4).

As part of the learning labs, participatory group activities provided opportunities for “instantaneous connections” across stakeholder groups, or conversation “seeds” which could be followed up later (3, 12). Serious games allowed people to be “playful with serious intent” and helped participants express themselves more freely (1, 11). Collaborative exercises (e.g., issue mapping) gave people a “point of engagement and a way of expressing their perspectives” (3) and participation by researchers in these exercises demonstrated that they were “equal interested parties” (9). In some cases, researchers shared responsibilities with non-academic actors to demonstrate shared ownership of the process (e.g., collaboratively organising and co-hosting the final FRACTAL learning event) (4). This was a big shift from “conventional workshops” (2). Good facilitation dealt with tensions effectively and kept everyone “safe” while participating in more “risky” participatory and emergent activities (2, 10, 13).

Research coordinators in cities and at the central project level played an important administration and “yoga-style” leadership role (2, 3, 7, 13). Research coordinators in cities were particularly important for connecting disciplinary research processes to the local context on an ongoing basis (3). The local teams of principal investigators, embedded researchers and a contact point within the municipality enabled a more relational way of working in cities because these team members lived in these contexts and understood many of the experiences and challenges that were discussed during engagements (7, 10). Processes were supported particularly well in cities where contact points within government could “push and engage” FRACTAL work within their own institutions (7, 8, 11). The Memoranda of Understanding, which were established near the beginning of the project and signed by the coordinating institution, research institutions in cities and the local municipality, also created an enabling institutional environment (2, 7).

Meeting in diverse transdisciplinary teams frequently, and over a long time period, supported productive relationships across different disciplines (1, 8, 10, 11). Multiple virtual platforms were also used between engagements for collaborative design of activities, to share updates and inputs on various aspects of work that were being carried out in parallel, and collaboratively produce knowledge products (7, 1).

Common knowledge for undertaking collaborative transdisciplinary work on African urban climate risks

The context-led approach of the learning labs allowed participants to share concerns that were “agnostic” to climate science, which helped to reveal “what actually matters to people” (3). Several respondents noted the importance of “appreciate[ing] different motivations” of stakeholders across divergent practices and finding “common areas” during transdisciplinary engagements (3, 4, 7). Participatory activities also surfaced tensions that exist across different cultural and work contexts (2, 10, 11).

Researchers learned about the challenges that are faced on a day-to-day basis by participants in cities, which differ across cultural, material and social contexts (e.g., across different government departments) (4, 7). Such challenges include inter alia limited resources to undertake service delivery functions, siloed planning and activities, limited coordination and limited understanding of issues at the political level (4, 10). Researchers also learned about the institutional structures within which decisions take place, which influence whether climate-related planning and action can be effective (7). Two of the respondents noted the large variety of experiences across landscapes in African cities when compared with cities in developed country contexts and emphasised the importance of hearing about these

different experiences to understand other participants better (6, 10). This awareness helped to understand the potential “spaces for engagement” and the knowledge that might be useful for decisions (4, 7).

Researchers also learned about the factors that influence the potential of different stakeholders to engage effectively in collaborative learning processes such as FRACTAL (2). For example, representatives from NGOs participated less extensively in one of the FRACTAL cities because of their “slim” staff body when compared with government organisations. Respondent 4 noted the importance of understanding the knowledge paradigm of non-academic participants in cities, which influences their expectations from a project such as FRACTAL, as well as their personal “narratives” about the world. This is evidenced by the following quote from a researcher: “The university story of knowing, that’s how people think, that’s how they’ve been modelled over time. That’s the reality they know.” (4). FRACTAL was disruptive and its transdisciplinary framework was different to such traditional “university” knowledge paradigms. Champions within government organisations attended these labs and were therefore important to support this paradigm of knowledge creation (4).

A range of different engagements helped researchers to understand how participants positioned themselves in relation to climate risks and ongoing/potential resilience initiatives in cities, as well as how climate change information might be useful in decision making (10). Respondents emphasised the importance of understanding the politics and protocols, existing relationships and networks, as well as access to tools that supported or hindered ongoing objectives of non-academic actors relevant to dealing with climate risks (2, 4, 5). Spending time discussing decision contexts helped researchers to better understand the “learning needs” of organisations in cities (10).

Table 3 summarises the findings according to the capabilities of researchers, design considerations in “sites of intersecting practice” and common knowledge for undertaking collaborative transdisciplinary work on African urban climate risks.

Discussion

This discussion follows a similar structure to the results, reflecting on the findings according to capabilities of researchers participating in FRACTAL, characteristics of transdisciplinary spaces and the common knowledge that was developed as a result of these enablers.

The findings from the study point to the importance of the effort made by researchers to travel to cities across southern Africa, participate in transdisciplinary work on an ongoing basis, visit actors in their home spaces and show

Table 3 Relational enablers for researchers to work with non-academic actors during FRACTAL

Enabler type	Enabler
Capabilities of researchers	<p>Awareness of biases, blind spots, judgements and impartial knowledge</p> <p>Being explicit about what was learnt from non-academic actors</p> <p>Explicitly avoiding dominating with academic content, but supporting critical interrogation using content expertise in some cases</p> <p>Openness and letting go of personal agendas (“porous”). This includes inviting stakeholders into academic work (including scepticism)</p> <p>Responding to needs in the transdisciplinary team and in cities (commitment to the local needs)</p> <p>Increasing attentiveness and tendency towards collective concerns and becoming increasingly involved in the design of transdisciplinary processes</p> <p>Constantly “showing up”, spending time with other participants and engaging in active dialogue in context</p> <p>Exercising inter-personal skills: asking questions, reading body language, being sensitive to the evolution of conversation, being sensitive to contextual issues that might not be explicitly stated</p> <p>Communicating consistently using various platforms</p> <p>Drawing on social science expertise</p>
Design considerations in ‘sites of intersecting practices’	<p>Explicit co-production framing of interventions</p> <p>Involvement of strong-willed non-academic partners in project design</p> <p>Emergence of process design and permission to fail</p> <p>“Intense” shared transdisciplinary experiences</p> <p>Sustained and iterative engagements over time</p> <p>Transdisciplinary learning processes occurring away from “home” spaces</p> <p>Focussing on a burning issue to which many people could connect</p> <p>Including participatory group activities to create connections across actors</p> <p>Allowing for/encouraging being playful with serious intent during transdisciplinarity</p> <p>Deploying boundary tools and boundary processes that connect actors</p> <p>Good facilitation to keep participants safe</p> <p>Shared ownership of the process including co-hosting events between academic and non-academic actors</p> <p>Flexible leadership at multiple levels</p> <p>Contractually binding documents</p>
Common knowledge for undertaking collaborative transdisciplinary work on African urban climate risks	<p>What matters to people in their contexts</p> <p>Day-to-day challenges of participating actors, which differ across organisational settings</p> <p>Politics and protocols of organisations to which actors belong</p> <p>Access of actors to networks and tools</p> <p>The diversity of lived experiences across African cities</p> <p>Knowledge paradigms of actors, and their personal narratives of the world</p> <p>Potential climate champions</p> <p>Learning needs of actors and organisations</p> <p>Factors that influence the potential for actors to engage</p> <p>Expectations of participants in relation to projects/interventions</p>

attentiveness to the local needs. By showing an interest in the experiences and needs of non-academic actors and shifting research agendas accordingly, researchers demonstrated their own motivation to respond to collective concerns of navigating contextual climate risks. This was also demonstrated by avoiding dominating transdisciplinary spaces with academic content, but deploying scientific expertise

and information to support broader dialogues that were inclusive and relevant to local concerns. This suggests new capabilities for researchers involved in transdisciplinarity, particularly for sharing scientific information in accessible ways relative to societal concerns and building foundational understandings of this information (e.g., climate science) amongst non-academic actors such that it can be collectively

interrogated. By being more “porous” and explicit about learning from other actor groups, researchers supported a “dialogical space” as emphasised by Decuyper et al. (2010) (p. 117) and facilitated a contextual and relational learning process (Klein 2018).

Researchers exercised inter-personal skills during formal and informal engagements to better understand the perspectives, values and motives of non-academic actor groups. They were also sensitive to contextual issues that might not be explicitly verbalised by these actors, which aligns with the need to understand various rationalities within African cities, as described by Watson (2014) and Smit et al. (2021). The commitment of researchers to understand actors in cities might provide insights into how trust was built in a relatively short space of time. These efforts potentially contributed to mending a legacy of research as an extractive process, during which researchers have not been clear about their intentions while engaging other actor groups. With an expansive learning perspective, researchers have historically not been practicing relational expertise. During FRACTAL, researchers explicitly demonstrated their motivation for engaging in transdisciplinary work to respond to contextual, collective concerns.

Another new insight that was gleaned from this study, on capabilities for better understanding perspectives, values and motives of other actors relative to a common problem, relates to the influence of social scientists. These researchers drew on their academic training to work with non-academic actors in ways that allowed for “figur[ing] out the challenges and decisions that are trying to be made”. With a different training that does not emphasise the importance of understanding contextual nuances, natural scientists seem to have learned from social science practices while working in transdisciplinary teams.

While not explicitly designed as expansive learning interventions, the transdisciplinary learning labs created an environment that was conducive to growing common knowledge between academic and non-academic actors, which is essential for practicing relational agency to co-produce climate knowledge (Edwards 2017). The context-led approach of collectively deciding on and exploring ‘burning issues’ helped to reveal what mattered to people in their material (i.e., African city), work (i.e., organisational) and personal contexts. This understanding would likely not have been built in a traditional workshop setting. An understanding of the willingness and strengths of actor groups to respond to the burning issues was also grown. These collective processes helped participants better understand one another and identify similar goals, which are important enablers for growing common knowledge in ‘sites of intersecting practices’ (Edwards 2017). Importantly, activities that provided opportunities for researchers to connect with many groups helped them to

understand the diversity of values, perspectives and motivations across heterogeneous groups of actors living and making decisions in African cities.

The findings point to the importance of the involvement of strong-willed, non-academic partners from the beginning, which created space for non-academic actors to voice their opinions. Transdisciplinary learning processes were emergent and iterative, allowing for responses to be designed based on an understanding of the perspectives, values and motives of different participants. As such, common knowledge was grown between participants, which could be used as a relational resource to co-produce climate-related knowledge (Edwards 2017). Participants also learned about each other through free-flowing dialogue, informal engagements during tea and lunch breaks, and while they spent time together in locations away from home or workspaces. The findings suggest that transdisciplinary spaces that supported the growth of common knowledge were enabled by features beyond the labs such as contractually binding agreements and leadership at various levels. This finding reminds us of the importance of systemic and relational features as described by Cundill et al. (2019).

In line with Decuyper et al. (2010), the findings suggest that the relational capabilities of researchers and the design of transdisciplinary activities shaped one another over time. The co-production framings allowed researchers to practise their relational capabilities from the very beginning, while they were provided opportunities to reflect on learning processes in transdisciplinary teams. This finding also underscores the situated and dialectical nature of learning in a particular context i.e., that the transdisciplinary context influenced learning and change for researchers (Engeström 2001). In the case of the FRACTAL researchers, they increasingly improved their relational capabilities as they engaged in transdisciplinary spaces, which were different from traditional research spaces.

The study adds insights on common knowledge that can be grown such that researchers can better work with non-academic actors to co-produce knowledge on climate risks in African cities. Researchers learned what matters to different actor groups by spending much time exploring the burning issue from multiple perspectives. They also learned about the capacities, information, networks and tools that support work of non-academic actors, and ways in which these might be strengthened, or gaps filled. Researchers emphasised the importance of understanding the knowledge paradigms of non-academic actors, and personal narratives of how the world works, also in line with the concept of rationalities (Smit et al. 2021; Watson 2004). Researchers learned that non-academic actors in African cities face a particular set of challenges including the cultural and institutional structures that hinder their agency to engage in co-productive spaces and/or make progress in terms of climate-related objectives.

While understanding tensions inherent in the work of non-academic actors seems to be in contrast with the need to understand “motivation” as described by Edwards (2017), tensions are fundamental when considering human activity as people must practise agency to overcome these towards common objectives, which, in turn, is integrally connected to motivation. As opportunities for transforming their activities, the challenges that non-academic actors face are therefore inextricably and dialectically interlinked with their motivations and practices. The “champions” identified by researchers can be considered those subjects who initially took agency (i.e., put in extra effort) to engage with these tensions and driving systemic change towards an expanded objective (i.e., multi-actor transdisciplinarity for co-producing knowledge) despite traditional knowledge paradigms and siloed ways of working.

Many of the findings from this study align with previous studies on enablers for collaborative transdisciplinary work. However, with an expansive learning perspective, there is a stronger emphasis on the enablers, both in terms of capabilities and/or design considerations that help to understand the perspectives, values and motives of diverse actor groups relative to a common problem, and to make one’s own explicit. In FRACTAL, researchers practised and developed capabilities to understand the perspectives, values and motives of non-academic actors relative to navigating climate risks in their urban context. Importantly, the capabilities that they exercised and spaces in which they engaged also shed light on their own perspectives, values and motives.

It is important to reflect on the scalability of findings from this study. Expansive learning emphasises the situated and dialectical nature of collaborative learning (Engeström and Sannino 2021). To grow common knowledge, researchers participating in transdisciplinarity need to be responsive to the perspectives, motives and values of the non-academic actors with which they work. Common knowledge is dependent on the actors involved (who are rooted in particular cultural and historical contexts) and the problem on which they are working (Edwards 2017). The capabilities exercised and grown by researchers during FRACTAL and activities that were included in transdisciplinary spaces helped to grow common knowledge that enabled them to co-produce knowledge with non-academic actors for navigating complex climate risks in African cities. While many of the capabilities and transdisciplinary activities will likely contribute to enabling relational work in other contexts, researchers should remain lively and dynamic to respond to collaborators and problems situated in other contexts.

Conclusion

This study shines light on the enablers of effective transdisciplinary collaboration for researchers to work with non-academic actors to co-produce knowledge on complex climate risks in African cities. Findings from the study contribute to the body of knowledge on practices and processes for effective transdisciplinary collaborations. Expansive learning provided new perspectives to enrich this body of knowledge, particularly by considering the capabilities of researchers and design elements of transdisciplinary spaces that are required for researchers to make their perspectives, motives and values known, and to build an understanding of what drives and challenges non-academic actors in African cities.

Findings from the study highlight the importance of effort made by researchers to engage non-academic actors in their city contexts and to respond to local priorities through various practices and activities. FRACTAL researchers made efforts to be part of local transdisciplinary communities across cities that could develop collective understandings of climate-related issues and design responses based on the strengths of various actor groups participating in the learning processes. Design elements that enabled relational work included an explicit co-production framing, sharing experiences together and flexible project structures and dialogue that allowed participants to connect. The study highlights the dialectical relationship between growing relational capabilities of researchers and their engagement in transdisciplinarity, provided spaces are created for reflection on these activities.

Transdisciplinarity helped researchers to understand the challenges that non-academic actors in cities face, the cultural and institutional structures that enable or hinder their agency, the variety of heterogeneous experiences, knowledge paradigms and personal narratives, as well as the many ways that non-academic actors are already responding to climate risks. Since these dynamics influence the motivation of non-academic actors, common knowledge was grown, which helped researchers to take action according to the offerings and needs of non-academic actors across cities.

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Data availability For reasons of anonymity, the data that support the findings of this study are not readily available. However, if necessary, the author can make available anonymized data upon reasonable request.

Declarations

Conflict of interest The author declares no conflicts of interest.

Ethical approval The study was conducted in accordance with the University of Cape Town ethics protocol (<http://www.researchsupport.uct.ac.za/ethics-0>) and the protocol was approved by the Ethics Committee of Science Faculty (FSREC 008-2020).

Informed consent All subjects gave their informed consent for inclusion before they participated in the study.

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