How to build Theories of Change for transdisciplinary research: Guidance and considerations

A Theory of Change (ToC) is a set of testable hypotheses that model how an intervention will contribute to a change process. ToC development and use can help in the design of transdisciplinary research to build trust and accountability in the research process. We present an online process for ToC facilitation and offer guidance to collaboratively build a ToC for transdisciplinary research.

Rachel Claus, Rachel Davel, Cheryl Heykoop, Daniela Pinto, Brian M. Belcher

How to build Theories of Change for transdisciplinary research: Guidance and considerations
GAIA 32/1 (2023): 186–196

Abstract
Transdisciplinary research (TDR) aims to solve problems in complex systems by drawing from a range of methods and expertise to contribute to change processes. Theories of Change (ToCs) are well-suited to support TDR design and implementation, but they rarely achieve their full potential. In practice, ToCs are often compromised by insufficient engagement with the context, weak theoretical bases, poor articulation, and a lack of iteration. This paper presents a process for ToC design based on the authors' experience facilitating ToC development for research planning and evaluation. We illustrate the process using an in-progress TDR example on patient-oriented cancer care research. The approach begins by framing the social and research problems and then identifies activities and outputs, key actors, outcomes, and underlying causal assumptions. Skilled facilitation and strong conceptual familiarity are key to effectively mobilize ToC concepts into a cohesive and testable model to refine a strategy with TDR stakeholders. Key considerations and resources are offered to enhance ToC development planning and facilitation.

Keywords
patient-oriented cancer care research, research effectiveness, research impact, research planning, Theory of Change, transdisciplinary research

Transdisciplinary research (TDR) emerged in response to the limitations of disciplinary knowledge to address dynamic, multi-dimensional, and global challenges (Max-Neef 2005). TDR approaches cross disciplinary and institutional boundaries to include stakeholders in the research process to foster more socially robust knowledge and devise solutions to problems in complex systems (Nowotny et al. 2003, Pohl et al. 2021, Rigolot 2020). The problem-specific nature and importance placed on societal relevance and engagement are widely accepted as defining characteristics of TDR (Carew and Wickson 2010, Lang et al. 2012, Pohl et al. 2021). As a result of TDR's orientation toward transformation, questions about how projects can achieve societal impact and how the societal impact resulting from research contributions can be measured have been central to scholarly debate (Schäfer et al. 2020). The development and use of a Theory of Change (ToC) offer a structured way to plan for impact in TDR, by making the underlying causal logic of an intervention explicit and testable. ToCs are widely used in philanthropy (James 2011), international development (Stein and Valters 2012), government, and the private sector. ToCs have been applied successfully to TDR. ToCs can be used as analytical frameworks to help hone research strategies and provide convincing accounts of TDR's societal value to secure future funding (Deutsch et al. 2021), enhance reflexive capacity (Oberlack et al. 2019), improve outcomes (Schneider et al. 2019), and evaluate the impact of TDR (Belcher et al. 2020, Temple et al. 2018). Yet, there is limited documented experience of how to develop and apply ToCs for TDR planning and adaptive management (Armitage et al. 2019, Deutsch

Rachel Claus, MSc | Royal Roads University | Sustainability Research Effectiveness Program | College of Interdisciplinary Studies | Victoria, BC | CA | rachel.claus@royalroads.ca

Rachel Davel, MDev | Royal Roads University | Sustainability Research Effectiveness Program | College of Interdisciplinary Studies | Victoria, BC | CA | rachel.davel@royalroads.ca

https://doi.org/10.14512/gaia.32.1.18
Received June 29, 2022; revised version accepted March 9, 2023 (double-blind peer review).

Assoc. Prof. Cheryl Heykoop, DSocSci | Royal Roads University | School of Leadership Studies | Victoria, BC | CA | cheryl.1heykoop@royalroads.ca

Daniela Pinto, MA | Royal Roads University | Sustainability Research Effectiveness Program | College of Interdisciplinary Studies | Victoria, BC | CA | danielapinto0@gmail.com

Prof. Brian M. Belcher, PhD | Royal Roads University | Sustainability Research Effectiveness Program | College of Interdisciplinary Studies | Victoria, BC | CA *and* Center for International Forestry Research | Bogor | ID | brian.belcher@royalroads.ca

et al. 2021). Thus, practical guidance is required to support the use of ToCs for TDR.

We draw on our experience facilitating ToC development for application to research evaluations (over ten case studies). In most cases, we documented the ToC ex-post rather than at inception, which misses opportunities for reflective processes to be built in to stimulate learning during the research process. We also draw on observations from facilitating ToC training in over 20 doctoral student projects. We tested the ToC development method using the fishbowl facilitation style (Sutherland et al. 2012) in four workshops to date.

For those seeking to design, evaluate, and fund TDR, the guidance presented herein can help develop tailored ToC processes to query the causal logic of research interventions for their contributions and possible returns on investment. We begin by discussing and defining the attributes of ToCs that complement TDR. We then describe the steps of a ToC process, as illustrated by an early design-stage TDR project about transforming cancer care for young adults in British Columbia (BC), Canada. We developed an initial ToC for this project in real time in an online workshop held at the *2021 International Transdisciplinarity Conference (ITD21)*. We offer a theoretical understanding and practical application of ToC processes, as well as suggest resources for effective ToC use to support TDR.

Challenges, needs, and opportunities for Theories of Change in a transdisciplinary research context

TDR is arguably better suited than disciplinary research to address complex social problems, as it responds to the needs and priorities of those who affect and are affected by a given problem (Lang et al. 2012, Max-Neef 2005, Westberg and Polk 2016). Integration of diverse expertise and values is assumed to cogenerate a more representative (i.e., relevant, credible, legitimate) understanding of systemic problems which leads to solutions (Cash et al. 2002, Pohl et al. 2021, Westberg and Polk 2016). TDR researchers are experimenting with novel approaches, providing the opportunity to learn about what works to achieve results. The empirical basis for TDR's potential for transformation would be strengthened with explicit tests of whether and how TDR addresses complex problems (Pärli et al. 2022). ToCs provide a structured framework and process to do so.

A research ToC is a set of hypotheses about the causal relationships between an intervention's activities, outputs, and resulting outcomes and impacts. It models the change process to which the research aims to contribute, represented by a diagram and/or narrative explanation that can be used as an analytical framework for research design, evaluation, and learning (Belcher et al. 2020). Thus, a ToC must consider the characteristics of the system the research aims to influence, the societal challenges, the progress made to date, and the opportunities for and barriers to the desired change. While research proposals provide some of this information, uncovering the causal logic of a research intervention using a participatory process makes the ToC explicit, testable, and actionable. It provides an otherwise absent basis on which to advance knowledge on the supposed and actual impacts of TDR, which can then be measured and reflected upon throughout the project.

Collaborative development and use of a ToC aim to stimulate joint reflection and adaptive management at each project stage to encourage high-quality TDR co-production that is context-based, pluralistic, and goal-oriented (Norström et al. 2020, Oberlack et al. 2019). When developed collaboratively, ToC processes co-identify: 1. the social problem that the research aims to address, which helps define the research purpose and inform the strategic design of 2. the activities and outputs that will contribute to 3. the outcomes. This facilitates engagement with the problem context, as well as critical reflection on the role of research in the intended change process. The problem context includes the aspects of location, scale, socio-ecological conditions (e.g., culture, environment), and status or maturity (Carew and Wickson 2010). Using a ToC process to define the research problem and design the research approach collaboratively helps ensure relevance, broadens the knowledge base for strategic and context-responsive research design, and facilitates shared ownership of the project and its goals (Douthwaite and Hoffecker 2017, Van Drooge and Spaapen, 2017, Oberlack et al. 2019).

The integration of diverse knowledge across disciplines and professions is a strength of TDR, but it can also be a source of conflict for transdisciplinary teams when ideas misalign. Thus, TDR processes require integration expertise (Hoffmann et al. 2022). Mental models of change processes often differ according to individual worldviews and experiences (Deutsch et al. 2021). The process of developing a ToC provides a structure for all stakeholders to examine their own and others' ideas and assumptions about how change is expected to manifest, to build a shared vision.

However, inclusive ToC development can pose practical challenges; the logistics to assemble teams and stakeholders in one physical space is a key example. Online workspaces provide an alternative, but the online environment has its limitations. Virtual meeting fatigue has decreased engagement and communication within and between teams, hindering effective collaboration (Waizenegger et al. 2020). Moreover, online spaces may not be sufficiently engaging or appropriate for some TDR stakeholders. Online and in-person gatherings alike are subject to the effects of power dynamics, limiting equitable inclusion and allowing certain personalities to dominate the conversation (Fritz and Meinherz 2020). Well-facilitated ToC processes should account for these factors.

Facilitating a Theory of Change process online for transdisciplinary research

All authors of this article have experience with in-person ToC development processes, but COVID-19 required online adaptation. The virtual *ITD21* offered an opportunity to showcase an >

online ToC process in a workshop[1] setting, the purpose of which was to demonstrate the approach using a new research project as an example. *ITD21* workshop participants had various TDR expertise (e. g., evaluation, sustainability science, transformation, energy citizenship, funding support). They observed and helped document the project ToC in real time, building literacy in key concepts and gaining hands-on experience with conceptualizing and developing a TDR ToC.

A three-year participatory action research project was presented in the *ITD21* workshop. The project focuses on improving cancer care for young adults in BC through direct engagement with patients and a network of cancer care allies (e. g., oncologists, healthcare leaders, community organizations, families), and it was conceptualized with representatives of these stakeholder groups. It seeks to share the lived experiences of young adults with cancer, identify their care needs and priorities, develop and pilot actions to improve BC's young adult cancer care, build capacity for patient-oriented research and practice, and inform change in young adult cancer care research, policy, and practice. The *ITD21* workshop offered the researcher an opportunity to develop a first draft ToC for the project (still in its proposal phase) to align research activities with intended changes for patients and the cancer care system.

The approach is replicable with larger and more diverse groups. In a typical process, the first draft of the ToC would be co-developed with stakeholders, but that was not done in this demonstration. The researcher intends to develop the ToC further with project partners. Each phase of the ToC process (preparation, workshop, follow-up) is explained below using the example project, and researcher reflections are provided.

Preparation

Participation and time requirements vary according to project complexity (e. g., budget, personnel, timeline). ToC workshops are typically run over two or more days, requiring eight to 15 hours total. An hour is normally spent reviewing concepts and at least an hour is spent per element (i. e., purpose, activities, outputs, outcomes, impacts) to document a first draft ToC. Defining outcomes often requires more time to distinguish intermediate, end-of-project, and high-level outcomes. Once a first draft is developed, impact pathways and assumptions can be identified, as intended changes (e. g., policy, organization practice) can be grouped and the causal logic can be questioned.

We designed our *ITD21* workshop to meet the following objectives: 1. provide a conceptual orientation, 2. mobilize concepts with participants, and 3. develop a first draft ToC. For the three-hour conference session, we compressed the conceptual and technical overview into 30 minutes and adjusted time allocations to work through each ToC element equally quickly. This was possible as the researcher was the sole representative of the project, and discussion could be expedited using the fishbowl format. The customized online whiteboard (figure 1) used spheres of control, influence, and interest (Montague 2000) as a structure to document the ToC.

Definition and delegation of roles will vary depending on group composition. In this case, the facilitators were not project team members but rather guides of the process to gather the opinions and ideas of participants (Axner no date). Roles (figure 2, p. 190) were decided amongst the facilitation team according to preference and experience.

We met with the researcher (one of the co-authors of this paper) in advance to discuss the process, manage expectations, and request documentation. Reviewing the proposal and other documents helps facilitators build familiarity with the project context, shape ideas about what ToC elements might emerge, identify gaps in causal logic, and inform lines of questioning suitable to the project context.

> *The preparation helped to get a sense of the workshop flow and expectations of my role in the ToC process. Conversations with the facilitation team helped me to more clearly and concisely convey the study's aims, objectives, and expected outcomes. As I was the only member of the research team present for the ITD workshop, it was important to understand that this was a first step, and additional ToC processes involving stakeholders would be beneficial to pursue.*
>
> researcher

Workshop

The *ITD21* workshop began by introducing participants to the objectives, agenda, process, and an explanation of roles (figure 2). We then provided a conceptual overview with precise definitions of each ToC element to ensure a common understanding (Belcher and Halliwell 2021). Participants working to develop a ToC must use common language; in practice, key terms in logic models, ToCs, and discussions of research impact are often used ambiguously and with considerable overlap (Belcher and Halliwell 2021). This causes unnecessary confusion and undermines efforts to generate a shared vision. Introducing precise definitions of key terms[2] can serve to facilitate a common understanding, after which facilitators must remain alert to other definitions used by participants. Even the term "ToC" itself can cause confusion, as it may suggest that a ToC is a single theory (Deutsch et al. 2021). Rather, a ToC represents a set of multiple testable hypotheses that model how an intervention will contribute to a change process (Belcher and Claus 2020). Nested spheres of control, influence, and interest were presented to illustrate where ToC elements reside and help ground ToC concepts within the research and wider change processes (Montague 2000). We also provided a tutorial on the online whiteboard software (*MURAL*™) for participants to practice using the workspace and its functions.

The *ITD21* workshop used a fishbowl facilitation style, but many formats are possible. Fishbowl approaches promote active

1 A workshop brings stakeholders "together to seek their opinions, extract their knowledge and [...] solve problems in a collaborative and creative environment" (Jisc 2012, para. 1).

2 Activity, output, outcome, realized benefits (Belcher and Halliwell 2021), social problem, research problem, purpose, assumptions (Belcher et al. 2016, 2020).

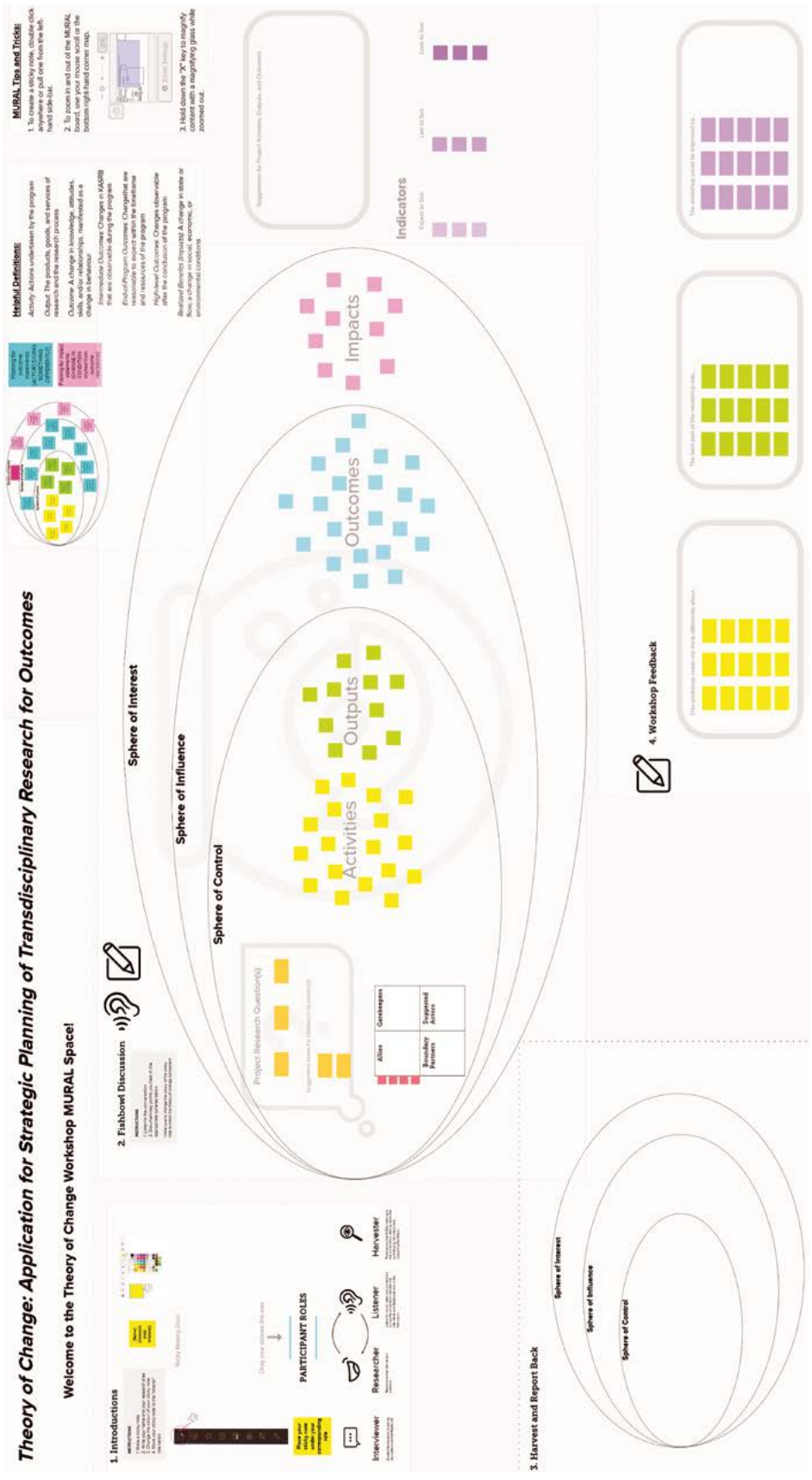

FIGURE 1: Example layout of a whiteboard[a] tailored to a virtual Theory of Change (ToC) workshop. The following elements of the whiteboard will be discussed in detail below: workshop roles (figure 2, p. 190), output of the fishbowl process structured in spheres of control, influence, and interest (figure 3, p. 191), target audiences (figure 4, p. 192), and harvest (figure 5, p. 193).
a *https://app.mural.co/t/changethenow8156/m/changethenow8156/1631299645087/f5bdc50f6430c8fb362c8672bb0ee3bc825765cc?sender=uc588ad163f865bdb900a0398*

FIGURE 2: Facilitator and participant roles in our Theory of Change (ToC) workshop session at the *2021 International Transdisciplinarity Conference (ITD21)*.

learning, and they are structured according to a working group (the interviewer and researcher) and an observer group (workshop participants) (Sutherland et al. 2012). The interviewer posed a series of questions to the researcher to stimulate thinking and elicit information about the project (see the ToC section of table 1, p. 194). Participants were instructed to listen to the conversation and record key ideas that fit each ToC element within its corresponding sphere (figure 3).

A review of project documentation helped prepare the facilitators, but it was important for the interviewer to listen actively to probe into the responses, reveal implicit or new ideas, and guide the researcher to focus on each ToC element.

The fishbowl began by defining high-level changes to which the research aims to contribute, all of which are outside the project's direct influence in the sphere of interest (Montague 2000). The discussion was framed to consider the social problem, knowledge-practice gaps, and the research problem to derive the overarching purpose of the project. The interviewer posed questions about numerous aspects of the societal issue and the role of the research in addressing it. This approach is used to prompt researchers to fully explore and discuss their motivations, research entry points, perspectives of the change process, and how the research will support expected changes (Thexton et al. 2019). The purpose of the example project was "cancer care systems deliver optimal quality care to young adults in BC and beyond".

The interviewer and researcher next discussed elements within the sphere of control, including the operational environment over which the project has direct control (i.e., activities, outputs) (Montague 2000). This process used backcasting (i.e., worked backwards from the purpose specified in the sphere of interest to identify supporting elements in the sphere of control) to determine what the project needs to do and what knowledge it will produce. ToC processes are iterative and use a combination of forecasting and backcasting (Thexton et al. 2019). The discussion identified key system actors (potential allies, gatekeepers, boundary partners) and considered their needs and the opportunities to inform, support, and influence them (figure 4, p. 192). Eliciting precise output statements in early planning phases can be difficult, as the research findings are yet unknown. For example, one output identified in the ToC was "co-identified solutions for young adult cancer care". At this stage of the research, solutions are not yet developed, but planning and documenting these ideas ensures that activities (e.g., "facilitate multi-stakeholder dialogue with young adults and cancer care providers") are designed to generate the intended outputs.

The final fishbowl discussion focused on the sphere of influence to understand who is expected to do what differently as a result of the research and why (Montague 2000). The preceding step to identify main stakeholders helped frame who (i.e., key system actors) might be involved in and influenced by the project, which provided the basis to discuss their specific actions and how the research could influence them. For example, oncologists were identified as a key target audience to be influenced by the project. It was hypothesized that oncologists' involvement in the project will help them obtain a better understanding of patients' challenges and co-developed solutions, and they will tailor treatment and care to accommodate young adults' needs.

We next ran an exercise to identify a graduated set of performance indicators to aid in the assessment of the extent of outcome realization. For each outcome, sets of specific, observable, measurable, and useful indicators should be developed to facilitate reflection on progress.

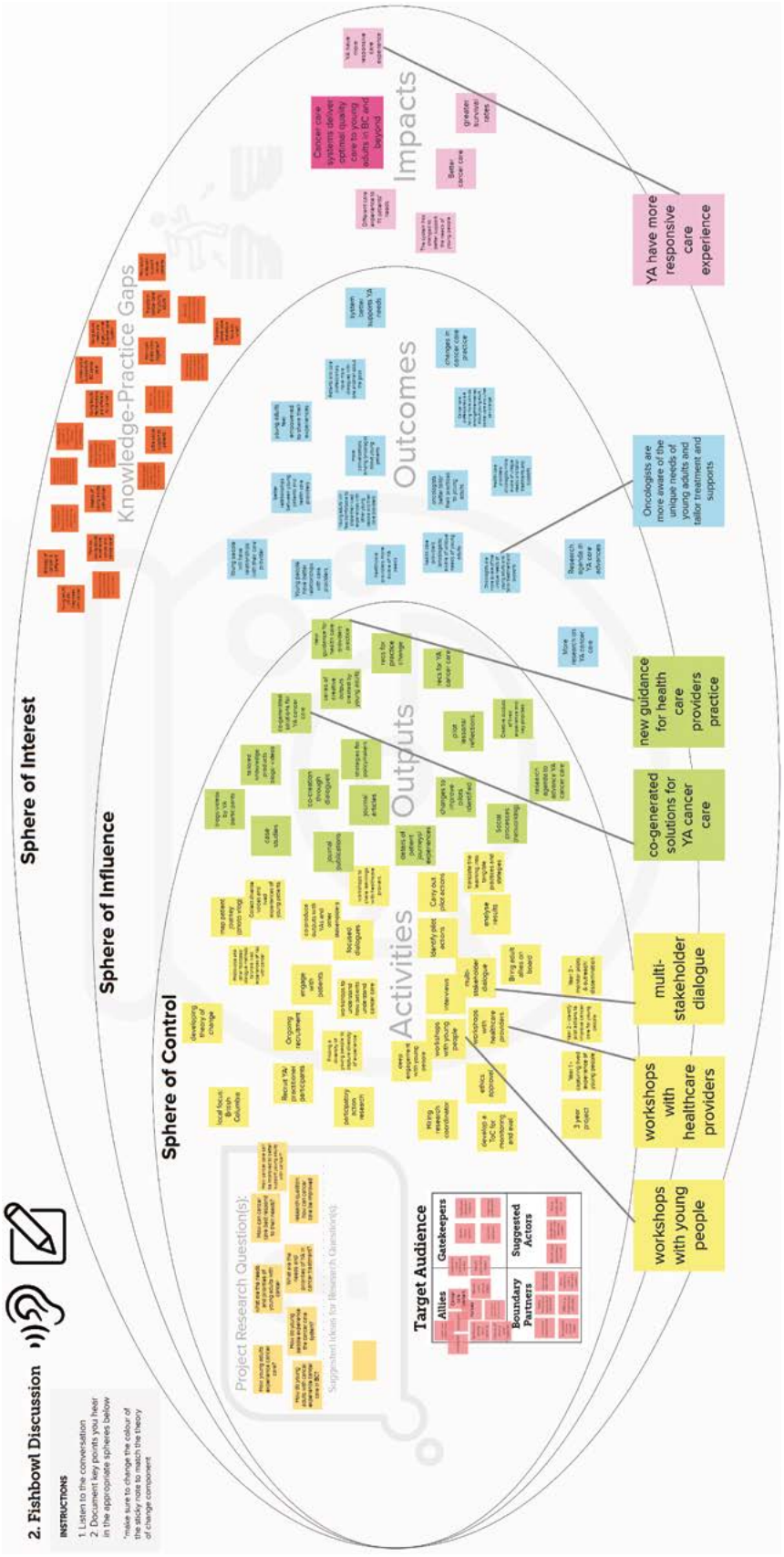

FIGURE 3: Example output of the Theory of Change (ToC) fishbowl process (participant sticky notes) on the transdisciplinary research project for transforming cancer care for young adults in British Columbia. *https://app.mural.co/t/changethenow8156/1646089737296/fd7fc3440057a3dfda5327369a137534d1dba09f?sender=u5ef8290c5315635b808f0514*

After completing the three fishbowl conversations to define the components within each sphere, the harvester (see figure 2 for a description of the role) presented a synthesis of the draft ToC developed during the session (figure 5, p. 193), including an explanation of the preliminary causal logic inferred from the discussion. The synthesis aimed to ensure ideas were accurately captured, and the subsequent discussion enabled scrutiny and validation with the researcher and participants. Conceptual orientation and active listening for key ToC elements in the discussion are critical to correctly frame the activity, output, outcome, and impact statements.

Assumptions in a ToC provide theoretical explanation for why it is reasonable to expect certain activities or outputs to cause or contribute to an actor taking a specific action. Despite the range of theories available to explain social change processes and system transformations (e. g., Stachowiak 2013, Kemp and Loorbach 2006), the theoretical grounding of ToCs' causal logic tends to be weak. Few ToCs draw explicitly on existing social theory to explain why changes (e. g., in behavior and policy) can be expected. Querying the causal logic for each outcome specified in a ToC provides an opportunity to engage with social theory (e. g., behavior change, applied policy theory) to provide more robust explanations of expected changes. This process enables participants to question assumptions that are usually implicit in project design to advance their understanding of the system in which the research intervenes. TDR projects might consider adding team members with social science expertise to help articulate applicable social change theory.

The next step of ToC development refines the causal logic. This was not done during the *ITD21* workshop due to time constraints, but it involves drawing arrows to represent hypothetical causal links between ToC elements and articulating assumptions for why one step connects with the >

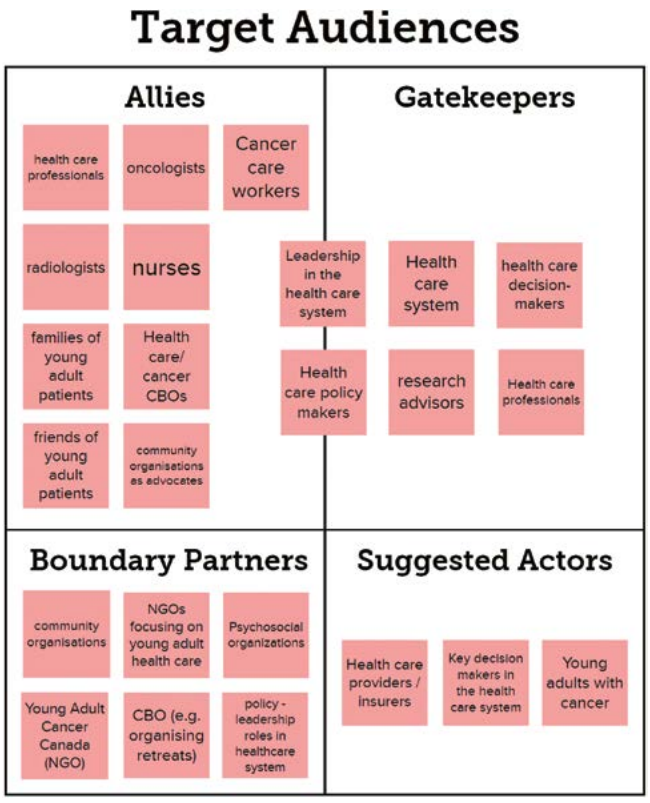

FIGURE 4: Target audiences: allies, gatekeepers, boundary partners, and suggested actors (examples from the transdisciplinary research project for transforming cancer care for young adults in British Columbia).

next in the causal chain. In a workshop setting, we ask participants to interrogate the causal logic of each outcome and explain why such changes would occur. For example, the interviewer questioned why oncologists would be expected to tailor treatment to young adults' needs. Why would they change practice based on pilots? One may suggest that their participation in the project would increase co-ownership and the likelihood that oncologists are convinced of the findings. The process to elaborate causal logic identifies gaps or missing steps and often surfaces unreasonable assumptions, which helps revise and refine project design and the ToC.

The ToC can then be organized into impact pathways, which are sets of activities, outputs, and outcomes that collectively contribute to a particular kind of change (e.g., government policy, healthcare practice, patient advocacy, etc.). Figure 5 shows preliminary thematic grouping according to three possible pathways (i.e., ally advocacy, patient empowerment, cancer care practice).

> *I was impressed with how easily the conversation flowed between the interviewer and myself. The questions posed were both open-ended and direct, and additional probes and guidance kept me on task. The process felt very supportive. I was equally awed by the amount of data generated during the session and the facilitation team's capacity to capture my ramblings in clear and coherent impact pathways.*
>
> researcher

Follow-up

Workshops yield a first draft ToC, but to be useful, mechanisms must be put in place to facilitate the iterative development, reflection, revision, and formative evaluation of the ToC (Oberlack et al. 2019). Often, the ToC development process ends at the first draft without further iteration and without taking advantage of its potential to inform strategy (Patton and Patrizi 2010). We typically work with project leads to refine the first draft ToC model and develop an explanation of the diagram. We then provide an opportunity for all participants to review the diagram and its narrative. Periodic re-engagement of TDR project stakeholders in ToC follow-up enhances transparency and co-ownership of outcomes, and keeps stakeholders involved in and accountable for planned activities to support the change process.

The ToC will evolve with the research process. Using a ToC involves reflecting on what process-related learning emerges. It enables teams to monitor progress, question whether and why change is happening as expected, and inform next steps. Key considerations include who is responsible for leading the mobilization of the ToC, how frequently review is needed, and who should be involved in the adaptive management of a TDR strategy. Delegation of responsibility is straightforward for an individual researcher, but requires a clear definition of roles within a team or TDR collaboration. One possibility is to use the ToC as a structure for annual research planning and progress meetings throughout the research cycle, including conversations about TDR project team members' roles, which will flow into iterations of the ToC itself.

> *I am excited about the possibilities the ToC offers to move the research forward. I am eager to share, validate, and refine the ToC with the project team and stakeholders, including young adults with cancer, health professionals, and key decision-makers to guide our research process. We plan to revisit, interrogate, and adapt the ToC and project activities annually to help maximize possibilities to contribute to meaningful and lasting change to young adult cancer care in BC and beyond.*
>
> researcher

Conclusion

The development and use of a ToC support an impact orientation in TDR by describing intended outcomes and the means to achieve them. The ToC development process can help in the design of relevant research that shares ownership of the process and its results with stakeholders. Defining, measuring, and reflecting on progress and paths to outcomes create opportunities for learning. Using a ToC promotes the transparency and accountability necessary to build trust in the research process. Table 1 (p. 155) summarizes key considerations derived from the authors' experience and shares resources to generate quality ToCs.

There are many ways to develop and use ToCs to accommodate diverse TDR project scopes, scales, and contexts. The lessons drawn from our experience provide a starting point to run

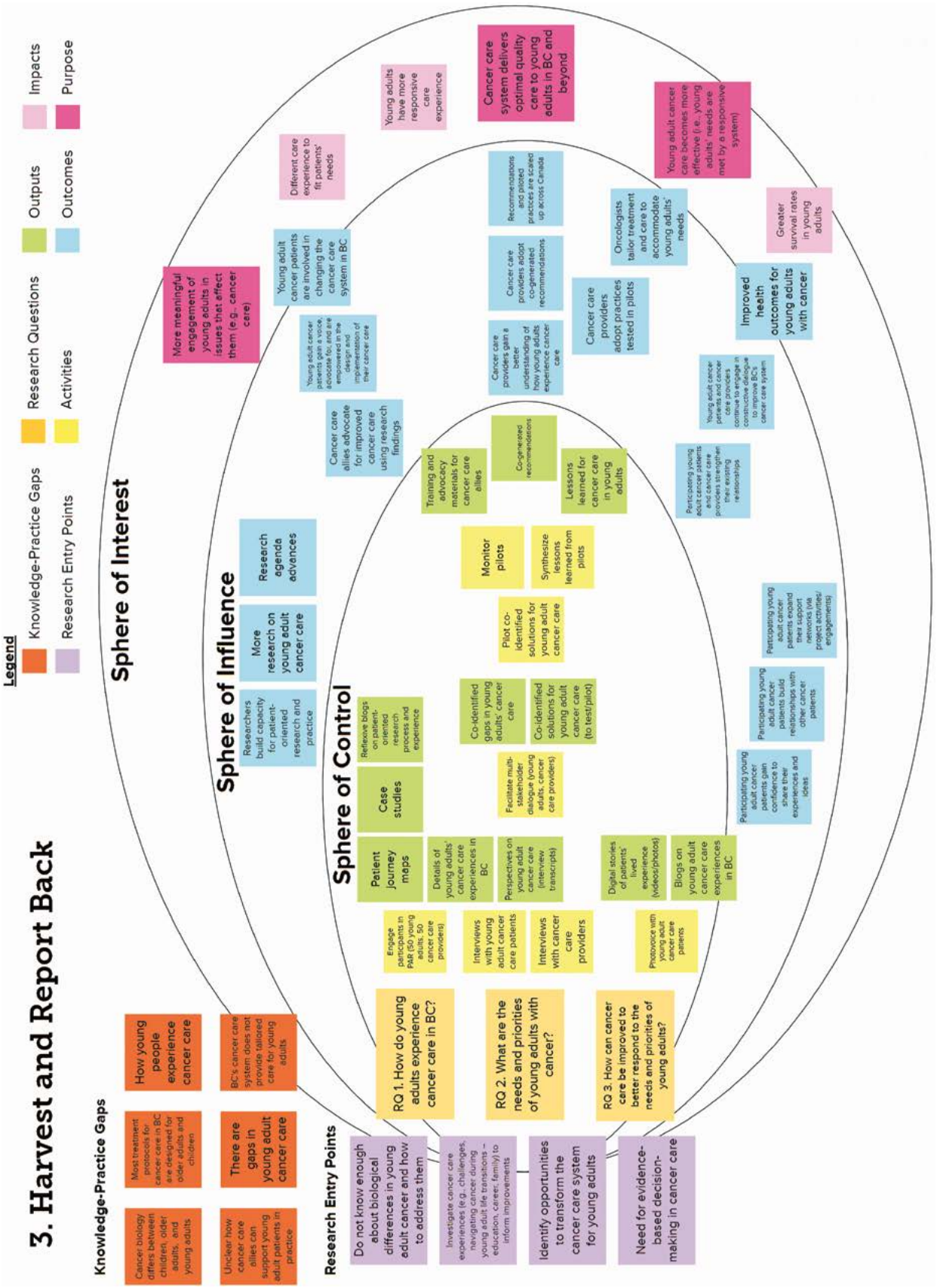

FIGURE 5: Harvest and report back: example of the harvester's synthesized Theory of Change (ToC) after completion of the fishbowl process (figure 3, p. 191).

TABLE 1: Considerations for Theory of Change (ToC) processes (the links to resources provided here are not exhaustive but aim to offer a collection of resources readers may find useful for each step in the process).

COMPONENT	CONSIDERATIONS	RESOURCES
PREPARATION		
project maturity	■ When in the research process is a ToC process needed? ■ How well-developed are project ideas?	ToC conceptual overview[a] workshop *PowerPoint* template[b]
participation	■ Who should participate? ■ Who can feasibly participate (availability, budget, logistics)?	
capacities	■ How familiar is each participant with ToC? ■ How much orientation do participants need? ■ What facilitation/soft skills are needed? ■ What familiarity with the problem context do facilitators need?	
WORKSHOP		
time management	■ How much time is needed for the process? ■ How much time can stakeholders allocate for the process?	infographic: ToC challenges and ways to overcome them[c]
participant buy-in	■ Do participants see the value of the process? ■ How can participants' expectations about the process be managed? ■ Do participants have reservations about the process? ■ What strategies or communications are needed to address concerns?	
group composition	■ What group composition will maximize genuine and explicit inclusion? ■ What tensions or conflicts may arise? How can they be mediated?	
integrating perspectives	■ How can equitable participation be facilitated? ■ How to capture and integrate diverse perspectives in the ToC? ■ How can mutual understanding and consensus be fostered?	
FOLLOW-UP		
iterativity	■ At what stages of the research should the ToC be revised (e.g., validation, updates, strategy sessions)? ■ Who is responsible for coordinating ToC use and iteration (adaptive management)? ■ Who is accountable for the ToC?	evidence table template[d] outcome monitoring tool template[e]
monitoring and evaluation strategy	■ What information do funders require? ■ At what stages will progress be monitored? ■ What indicators will be used to monitor progress? ■ What type of evaluation is needed? (e.g., formative, summative) ■ At what stages will evaluation be needed (ex-ante, interim, ex-post)? ■ How will evaluation data be collected, managed, and used?	
THEORY OF CHANGE		
defining the research purpose	■ What is the overarching goal to which the research aims to contribute but for which it is not accountable?	facilitating questions[f] model templates: spheres,[g] traditional[h] sample research ToCs: Belcher et al. (2019, appendix 3[i]) Belcher et al. (2022)
identifying target audiences	■ Who are allies/gatekeepers? ■ Who should ideally be involved in the research and how? ■ Who can feasibly be involved in the research and how (availability, budget, logistics)? ■ What are the parameters of engagement/participation for each actor in the research?	
articulating the research strategy	■ What will the project do? ■ What knowledge will the project produce? ■ What services/social process contributions will the project provide?	
specifying outcomes and assumptions	■ Who will do what differently as a result of the research findings and process? ■ How will intended outcomes be realized? ■ Why will the research contribute to change?	

a *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2019/08/Theory-of-Change-Toolkit.pdf*
b *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2021/09/Real-time-Presentation_ToC-Workshop.pptx*
c *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2021/11/ToC-Infographic.pdf*
d *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2018/09/Evidence-table-template.doc*
e *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2022/04/Outcome-Monitoring-and-Adaptive-Management-tool-1.docx*
f *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2019/02/Theory-of-Change-Facilitating-Questions.pdf*
g *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2018/10/spheres-Theory-of-Change-template.docx*
h *https://researcheffectiveness.ca/wp-content/uploads/sites/7/2018/10/traditional-Theory-of-Change-template.docx*
i *https://ars.els-cdn.com/content/image/1-s2.0-S1462901119304022-mmc1.pdf*

more effective ToC processes, which should be inclusive, fit for purpose, and guided by clear objectives. Grounded in these principles, a ToC can achieve a shared conceptual understanding, facilitate analyses of context and collective brainstorming on how a TDR project contributes to change, provide opportunities for participant capacity-building, and inform decision-making and learning (Oberlack et al. 2019). A good ToC process reveals and helps reconcile conflicting mental models and shifts the focus to solutions (Deutsch et al. 2021, Pohl 2011). With the provided guidance, researchers can mobilize ToC processes to optimize the impact of TDR and broader transformation.

Acknowledgement: We extend our thanks to the organizers of the *2021 International Transdisciplinarity Conference (ITD21)* where we facilitated a demonstrative Theory of Change workshop process. The session gave us an opportunity to test the process in real-time in an online space and engage with transdisciplinary researchers. We appreciate all those who participated in the workshop. We are grateful to *BinBin J. Pearce* and *Bianca Vienni-Baptista*, guest editors of this special focus, who invited us to share our insights and reflections from the workshop. We would like to thank the two anonymous reviewers for their helpful comments.
Funding: This work was supported by funding from *Ashoka*, the Canada Research Chairs Program, the Social Sciences and Humanities Research Council of Canada, the Vancouver Foundation, and Michael Smith Health Research British Columbia.
Competing interests: The authors declare no competing interests.
Author contribution: *RC, RD, CH, DP, BMB:* conceptualization, editing; *RC, RD, CH, DP, BMB:* writing – review; *RD, DP, BMB:* validation, input to workshop materials. *RD, CH, BMB:* workshop delivery; *RC:* writing – original draft, coordination and liaison, preparation and delivery of workshop materials; *RD:* preparation of figures; *CH:* project details; *DP:* workshop support. *RC* takes responsibilty as corresponding author.

References

Armitage, D. et al. 2019. Applying a theory of change process to facilitate transdisciplinary sustainability education. *Ecology and Society* 24/3: 20. https://doi.org/10.5751/ES-11121-240320.

Axner, M. No date. *Group facilitation and problem-solving: Developing facilitation skills.* https://ctb.ku.edu/en/table-of-contents/leadership/group-facilitation/facilitation-skills/main (accessed February 15, 2023).

Belcher, B., R. Claus. 2020. *Theory of change. td-net* toolbox profile 5. Bern: Swiss Academies of Arts and Sciences. https://doi.org/10.5281/zenodo.3717451.

Belcher, B., J. Halliwell. 2021. Conceptualizing the elements of research impact: Towards semantics standards. *Humanities and Social Sciences Communications* 8: 1–6. https://doi.org/10.1057/s41599-021-00854-2.

Belcher, B. M., R. Claus, R. Davel, S. M. Jones. 2022. Evaluating and improving the contributions of university research to social innovation. *Social Enterprise Journal* 18/1: 51–120. https://doi.org/10.1108/SEJ-10-2020-0099.

Belcher, B. M., R. Claus, R. Davel, L. F. Ramirez. 2019. Linking transdisciplinary research characteristics and quality to effectiveness: A comparative analysis of five research-for-development projects. *Environmental Science & Policy* 101: 192–203. https://doi.org/10.1016/j.envsci.2019.08.013.

Belcher, B. M., R. Davel, R. Claus. 2020. A refined method for theory-based evaluation of the societal impacts of research. *MethodsX* 7: 100788. https://doi.org/10.1016/j.mex.2020.100788.

Belcher, B. M., K. E. Rasmussen, M. R. Kemshaw, D. A. Zornes. 2016. Defining and assessing research quality in a transdisciplinary context. *Research Evaluation* 25/1: 1–17. https://doi.org/10.1093/reseval/rvv025.

Carew, A. L., F. Wickson. 2010. The TD wheel: A heuristic to shape, support and evaluate transdisciplinary research. *Futures* 42/10: 1146–1155. https://doi.org/10.1016/j.futures.2010.04.025.

Cash, D., W. C. Clark, F. Alcock, N. M. Dickson, N. Eckley, J. Jäger. 2002. Salience, credibility, legitimacy and boundaries: Linking research, assessment, and decision-making. *Assessment and Decision Making* (November 2002). https://doi.org/10.2139/ssrn.372280.

Deutsch, L., B. Belcher, R. Claus, S. Hoffmann. 2021. Leading inter- and transdisciplinary research: Lessons from applying theories of change to a strategic research program. *Environmental Science & Policy* 120: 29–41. https://doi.org/10.1016/j.envsci.2021.02.009.

Douthwaite, B., E. Hoffecker. 2017. Towards a complexity-aware theory of change for participatory research programs working within agricultural innovation systems. *Agricultural Systems* 155: 88–102. https://doi.org/10.1016/j.agsy.2017.04.002.

Fritz, L., F. Meinherz. 2020. Tracing power in transdisciplinary sustainability research: An exploration. *GAIA* 29/1: 41–51. https://doi.org/10.14512/gaia.29.1.9.

Hoffmann, S., L. Deutsch, J. T. Klein, M. O'Rourke. 2022. Integrate the integrators! A call for establishing academic careers for integration experts. *Humanities and Social Sciences Communications* 9: 147. https://doi.org/10.1057/s41599-022-01138-z.

James, C. 2011. *Theory of change review. A report commissioned by Comic Relief.* www.ngo-federatie.be/system/files/2018-11/2012-Comic-Relief-Theory-of-Change-Review-FINAL.pdf (accessed March 31, 2023).

Jisc (Joint Information Systems Committee). 2012. *Planning a participatory workshop.* www.jisc.ac.uk/guides/planning-a-participatory-workshop (accessed February 15, 2023).

Kemp, R., D. Loorbach. 2006. Transition management: A reflexive governance approach. In: *Reflexive Governance for Sustainable Development.* Edited by J.-P. Voß, D. Bauknecht, R. Kemp. Cheltenham, UK: Edward Elgar. 103–130.

Lang, D. J. et al. 2012. Transdisciplinary research in sustainability science: Practice, principles, and challenges. *Sustainability Science* 7/1: 25–43. https://doi.org/10.1007/s11625-011-0149-x.

Max-Neef, M. A. 2005. Foundations of transdisciplinarity. *Ecological Economics* 53/1: 5–16. https://doi.org/10.1016/j.ecolecon.2005.01.014.

Montague, S. 2000. *Circles of influence: An approach to structured, succinct strategy.* www.pmn.net/wp-content/uploads/Circles-of-Influence.pdf (accessed March 31, 2023).

Norström, A. V. et al. 2020. Principles for knowledge co-production in sustainability research. *Nature Sustainability* 3/3: 182–190. https://doi.org/10.1038/s41893-019-0448-2.

Nowotny, H., P. Scott, M. Gibbons. 2003. Mode 2 revisited: The new production of knowledge. *Minerva* 41: 179–194. https://doi.org/10.1023/A:1025505528250.

Oberlack, C. et al. 2019. Theories of change in sustainability science: Understanding how change happens. *GAIA* 28/2: 106–111. https://doi.org/10.14512/gaia.28.2.8.

Pärli, R., M. Fischer, L. Späth, E. Lieberherr. 2022. Transdisciplinary research for sustainable development – doing research about research. *GAIA* 31/4: 238–242. https://doi.org/10.14512/gaia.31.4.9.

Patton, M. Q., P. Patrizi. 2010. Strategy as the focus for evaluation. *New Directions for Evaluation* 128: 5–28. https://doi.org/10.1002/ev.343.

Pohl, C., J. T. Klein, S. Hoffmann, C. Mitchell, D. Fam. 2021. Conceptualising transdisciplinary integration as a multidimensional interactive process. *Environmental Science & Policy* 118: 18–26. https://doi.org/10.1016/j.envsci.2020.12.005.

Pohl, C. 2011. What is progress in transdisciplinary research? *Futures* 43/6: 618–626. https://doi.org/10.1016/j.futures.2011.03.001.

Rigolot, C. 2020. Transdisciplinarity as a discipline and a way of being: Complementarities and creative tensions. *Humanities and Social Sciences Communications* 7/1: 1–5. https://doi.org/10.1057/s41599-020-00598-5.

Schäfer, M., A. Lux, M. Bergmann. 2020. Editorial to the special issue "Transdisciplinary sustainability research – linking research processes and outputs to societal effects." *Environmental Science & Policy* 107: 206–210. https://doi.org/10.1016/j.envsci.2020.02.018.

Schneider, F. et al. 2019. Transdisciplinary co-production of knowledge and sustainability transformations: Three generic mechanisms of impact generation. *Environmental Science & Policy* 102: 26–35. https://doi.org/10.1016/j.envsci.2019.08.017.

>

Stachowiak, S. 2013. *Pathways for change: 10 theories to inform advocacy and policy change efforts.* Seattle: ORS Impact. www.evaluationinnovation.org/wp-content/uploads/2013/11/Pathways-for-Change.pdf (accessed March 31, 2023).

Stein, D., C. Valters. 2012. *Understanding theory of change in international development: A review of existing knowledge.* London: Justice and Security Research Programme.

Sutherland, R., K. Reid, D. Kok, Collins, M. 2012. Teaching a fishbowl tutorial: Sink or swim? *Clinical Teacher* 9/2: 80–84. https://doi.org/10.1111/j.1743-498X.2011.00519.

Temple, L. et al. 2018. Assessing impacts of agricultural research for development: A systemic model focusing on outcomes. *Research Evaluation* 27/2: 157–170. https://doi.org/10.1093/reseval/rvy005.

Thexton, T., B. M. Belcher, R. Claus, R. Davel. 2019. Evaluation for social impact: A theory of change Approach. In: *Ashoka U's: Evaluating changemaker education: A practitioner's guide.* 57–74. https://ashokau.org/media/416/download (accessed March 30, 2023).

Van Drooge, L., J. Spaapen. 2017. Evaluation and monitoring of transdisciplinary collaborations. *Journal of Technology Transfer* 47: 747–761. https://doi.org/10.1007/s10961-017-9607-7.

Waizenegger, L., B. McKenna, W. Cai, T. Bendz. 2020. An affordance perspective of team collaboration and enforced working from home during COVID-19. *European Journal of Information Systems* 29/4: 429–442. https://doi.org/10.1080/0960085X.2020.1800417.

Westberg, L., M. Polk. 2018. The role of learning in transdisciplinary research: Moving from normative concept to an analytical tool through a practice-based approach. *Sustainability Science* 11/3: 385–397. https://doi.org/10.1007/s11625-016-0358-4.

Cheryl Heykoop
Michael Smith Health Research BC Scholar and associate professor and program head of the Master of Arts in Leadership, Health Specialization at Royal Roads University, Victoria, BC, CA. Research interests: participatory action research, health leadership, creative action research, adolescent and young adult cancer care, health systems transformation.

Rachel Claus
Studies in geography, environmental governance, and research quality evaluation. MSc in sustainable development (Utrecht University, NL). Current *Doctor of Social Sciences (DSocSci) Program* student at Royal Roads University, Victoria, BC, CA; since 2016 research assistant with the *Sustainability Research Effectiveness Program,* Royal Roads University. Research interests: transdisciplinary research evaluation, research for development, sustainable development.

Rachel Davel
Studies in geography and international development. MDev in international development (Graduate Institute of International and Development Studies, Geneva, CH). Since 2017 research assistant with the *Sustainability Research Effectiveness Program,* Royal Roads University, Victoria, BC, CA. Research interests: transdisciplinarity, societal impact of research, theory-based evaluation, sustainable development in the Global South, urban agriculture.

Daniela Pinto
Studies in communication and transitional justice. MA in political science (University of Victoria, Victoria, BC, CA). Consultant on impact evaluation for public, private, and not-for-profit institutions. Research interests: comparative politics in the Global South, transdisciplinary research, impact evaluation.

Brian M. Belcher
Ashoka Chair in Research Effectiveness and professor in the College of Interdisciplinary Studies at Royal Roads University, Victoria, BC, CA. Leads a research program that is developing theory, methodology, and methods for evaluating research in complex transdisciplinary contexts to demonstrate the societal value and impact of research and learns lessons to improve future research.