

Towards Transdisciplinary Work

A short guide to Transdisciplinary Work (TDW) and its relevance for TNO

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Prologue



The martial arts master gave us the simple instruction: “Lower the stick”

Followed by a slight but significant detail: “And keep your fingers in contact with the stick at all times”

Six of us, three on each side, had the long rod resting on both our index fingers. As I was mentally preparing to lower my fingers the first inch, to my surprise, I noticed our stick going ... up?! My right-hand neighbour started giving firm directions

to our group “the stick needs to go down, not up!” but to my astonishment, the stick kept floating up further, to the point that I was almost standing on my toes, arms stretched up in the air. By now we were all nervously shouting instructions “Down! Not up!”. But somehow, nobody was lowering their fingers and the rod was hovering above our heads like a helium balloon.

Apparently, this happens all the time. The exercise is hence called ‘the helium stick’.

The helium stick exercise opened my eyes to why it is hard for a Transdisciplinary team to perform well. We tend to think that in order to reach project-goals, we need robust steering mechanisms, crystal clear instructions on who does what, embedded in an elaborate roadmap of where we are going. The more complex a project is, the more we rely on good management to steer through all the complexities.

More management on the stick lowering task however, would have amounted to nothing. Think about the ridiculous situation it would have caused if our instructor had started making sub goals (first we lower an inch, then another inch). Or if he had placed huge flashing neon arrows pointing in the correct direction “DOWN”. Or if he had handed out instruction manuals on ‘how to use your fingers’ muscles in a downward movement’. The task was straightforward, easy even, and we all knew how to do it. But nevertheless we failed. Why?

The helium stick, in all its simplicity, demonstrates that managerial measures are evidently pointless if we neglect the most important predictor for a team’s success: what happens between the team members. None of the individuals in my team had the intention to move the stick in the wrong direction, and none of us would have had this problem if we were to perform the task by ourselves. The involuntary upward movement of the stick is what happened because of the interaction of the six of us together.

The root cause of many helium sticks smacking up against the ceiling in TNO, is not a lack of good management. The problem is that our most ambitious and innovative research goals require the collaboration of experts in different disciplines that work in different fields. The key to successful teamwork is the ability of team members to make their differences in perspective, ideas, knowledge and values productive. And the bigger the differences, the bigger the challenge for the team, and the higher the rewards when the team members are indeed able to collaborate and combine their differences in creating an innovative and practical solution.

Reading guide

Welcome to this short guide to Transdisciplinary Work (TDW). Its purpose is to inform relevant people – such as business product owners, performance coaches, project leaders, team coaches, and HR – at TNO about the potential benefits of TDW and about what needs to be in place in order to facilitate TDW. This guide is based on our experiences of working in the ERP Wise Policy Making. Moreover, we would like to position this guide as a ‘work in progress’; we are currently in the process of both articulating and applying the insights and methods in this guide.

As a reader, you may first be looking for information that will help you understand the potential benefits and added value of TDW. Next, you may want to learn about how to organize and facilitate TDW. This guide addresses the following questions:

- What is TDW? And how is it different from other teamwork?
- Should TNO engage in TDW?
- What does a successful TDW team look like?
- What are the main principles behind TDW?
- What are the conditions that allow for TDW?
- What are examples of tools that we can use to improve my team’s TDW skills?

These questions are answered in the next chapters.

1. What is Transdisciplinary Work (TDW)?

Transdisciplinary Work (TDW) is best understood by comparing it to other approaches to research and innovation: monodisciplinary, multidisciplinary, and interdisciplinary (Bergmann et al., 2012: p. 41). When research output is described as multidisciplinary, interdisciplinary, or transdisciplinary, it suggests that several disciplines are combined in contemporary problem solving; see Figure 1 (please note that *mono*-disciplinary is *not* in the picture; it would be one circle).

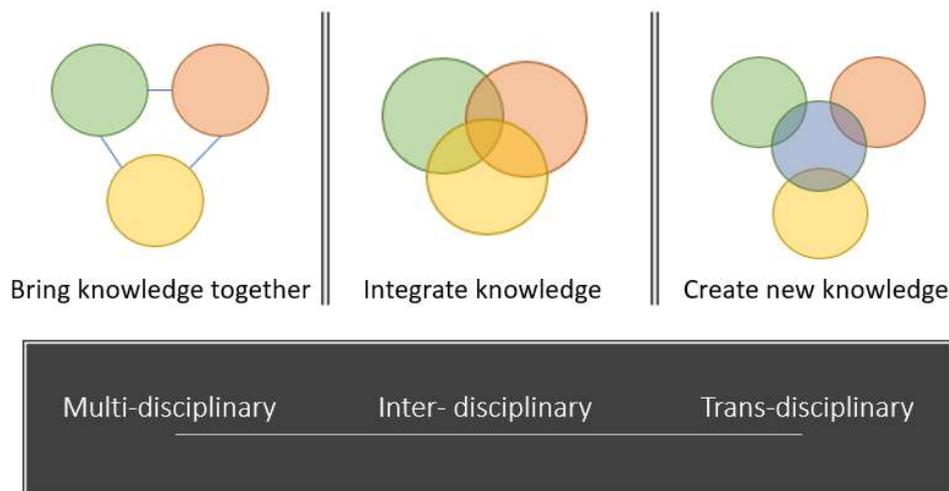


Figure 1: Characterizations of Multidisciplinary, interdisciplinary, and transdisciplinary approaches to research and innovation (monodisciplinary approach left out)

In a *monodisciplinary* approach, project team members have the same disciplinary background and they work together on a task within that discipline.

Multidisciplinary contrasts disciplinary perspectives in an additive manner, meaning two or more disciplines each provide their viewpoint on a problem from their perspectives. Multidisciplinary involves little interaction across disciplines.

Interdisciplinarity combines two or more disciplines to a new level of integration suggesting component boundaries start to break down. Interdisciplinarity is no longer a simple addition of parts but the recognition that each discipline can affect the research output of the other.

Transdisciplinarity occurs when two or more discipline perspectives transcend each other to form a new holistic approach. The outcome will be completely different from what one would expect from the addition of the parts. Transdisciplinarity results in a type xenogenesis where output is created as a result of disciplines integrating to become something completely new.¹

The objective of transdisciplinary work (TDW) is to understand the world in all of its complexities, instead of focusing on one part of it. This makes TDW particularly suited to address so-called 'wicked problems'; problems that are difficult - even seemingly impossible - to solve because of incomplete

¹ Entire paragraph from: <https://blogs.lt.vt.edu/grad5104/multiintertrans-disciplinary-whats-the-difference/>. Based on Lakehead University's "Essential Guide to Writing Research Papers,"

and contradictory data, interdependent causes and effects, and continuously changing dynamics that are often difficult to recognize.

Wicked problems benefit from a transdisciplinary approach because in a transdisciplinary context, scientists deeply integrate and transcend their disciplines in order to generate fundamentally new conceptual frameworks, theories, models, and applications” (see Figure 1). Through mutual learning, the knowledge of all participants is enhanced and these ‘new ideas’ are used to collectively devise solutions to intricate societal problems.

There is no recipe prescribing how to tackle a wicked problem. It is clear that a standalone new technology or a new kind of legal regulation will not be sufficient to help solve it. Wicked problems ask for combinations of innovations and interventions that have their roots in technology, law, ethics, psychology, sociology and policymaking. Some of these may be new, others well established in their discipline. And their mix is most likely an innovation in its own right. Wicked problems are thus likely to best be tackled by a team of experts from various disciplinary backgrounds, that have the ability to merge and transcend their knowledge and skills into a solution that did not exist before; a TDW team.

Below we will focus on transdisciplinary work (TDW); please note that much of what is relevant for TDW can also be relevant for multidisciplinary or interdisciplinary work—but as the complexity increases, the more a team benefits from a system’s perspective. This is why the systems perspective is most relevant for TDW and indeed inevitably necessary for organizing TDW.

2. Should TNO engage in Transdisciplinary Work?

Transdisciplinary Work (TDW) is not a magic tool. It does not guarantee any outcomes. And it most definitely will not warrant smooth sailing. What it will do? It opens an opportunity. A prospect to balance at the edge of the unknown and peer into the darkness, not knowing what you will find. Making the unknown productive, and finding practical solutions that make a difference.

Should TNO aspire to do TDW at all? The answer is twofold:

2.1 No, in many cases TDW is probably NOT what TNO should aspire to

Transdisciplinary work has quite a few disadvantages and risks:

- TDW is not always necessary - for regular contract research, consultancy work, and assignments at a higher TRL level ("tame problems"), a mono- or multidisciplinary collaboration is probably sufficient.
- TDW is difficult - it requires a delicate balancing act between exploring and diverging on the one hand and targeting and structuring on the other.
- TDW is demanding - it requires a high tolerance for frustration and calls on the patience of both management and project members to deal with "the edge of the unknown" and with uncertainty.
- TDW is uncommon - it requires additional skills from employees that TNO is not currently selecting for, and that are not in the development profile.
- TDW is an investment – it requires the time, capacity and financial legroom to invest in exploring the unknown area between disciplines.

- TDW is uncertain - the results are unpredictable and not easy to plan ahead in a work schedule like Ourplan or a timeframe.

2.2 Yes, in some cases TDW is TNO's unique "right to play":

There are circumstances in which TNO might consider practicing transdisciplinarity.

- TDW gives right to play on wicked problems² - the player that can combine multiple disciplines into new knowledge, qualifies for a place at the table by making a unique contribution.
- TDW offers international unicity in the scientific world³ - It is distinctive i.r.t. "Mission-oriented research & innovation" and universities (which often work in a mono- or multidisciplinary way)
- TDW makes TNO an attractive employer⁴ – TDW makes a challenging and interesting workplace for talented employees, where they learn to develop TDW competencies and apply them to complex social issues.
- TDW offers national appeal as a cooperation partner⁵ - the TDW "way of working & thinking" provides the basis for successful cooperation.



TNO has recently launched a large campaign with a slogan that focusses on our key strength: 'TNO connects people and knowledge to create innovations'. TNO has the potential to distinguish itself from many other players in the field (such as universities and knowledge institutes) with the ability to bring virtually all sciences together in one room. What TNO lacks however at this moment in time, is a (tailored) methodology and training program for its scientists that give them an edge on competitors in *how* they bring disciplines together. It is not enough to simply put several expert minds in one room. No matter how skilled and accomplished the scientists are, they still need a methodology that allows them to bring their expertise together and jointly lift it to the next level. And they need training and experience in how to work within this methodology. That is what TDW could add to the positioning of TNO as a thought leader in addressing today's most pressing societal problems.

² see strategic priority 1B 'vergroten impact' (right to play) & TNO brede risico's in Kaderbrief 2020

³ See priority 5 in the strategic plan 2018-2021 'internationalisering'

⁴ See priority 7 in the strategic plan 2018-2021 & strategische prioriteit 4 'huis voor talent'

⁵ See priority 4 in the strategic plan 2018-2021 'meer samenwerking'

3. What a TDW team looks like in practice

“Diverse teams typically either sorely underachieve, or they excel beyond expectations. The key difference between the two extremes is in the level of inclusion in the team; i.e. how well they deal with the differences”

Our team coach Mark J. Bouman

Before explicating the theoretical concepts behind TDW (in the next chapter), it is useful to understand what a TDW team looks like in practice. This chapter guides you along the three most important area’s that a TDW team works on; task, team and context. In addition, for an exemplary understanding of the practice of a TDW team, appendix I shows an example of the contents of a un-particular TDW team meeting that has been working together for almost a year.

An effective TDW team, first and foremost, discerns itself from all other types of teams by the content it generates; it produces new ideas, new solutions and new understandings that are relevant in the context of wicked problems.

Typically, this kind of team consists of 4-12 individuals with little common ground at the start, but with a shared goal: to create an innovation in order to address a *wicked* problem. This requires the effective combination of different fields of expertise while operating in a context with many diverse stakeholders and complex dynamics.

3.1 Work on task, team and context

In order to generate novel, creative ideas for wicked problems, a TDW team knows that it has work to do in three important area’s;

1. The task that needs to be done, e.g., conducting the research, producing results
2. The team that conducts the project, e.g., people with different backgrounds and expertise
3. The context, e.g., sponsors in the organisation, other organizations, the outside world, etc.

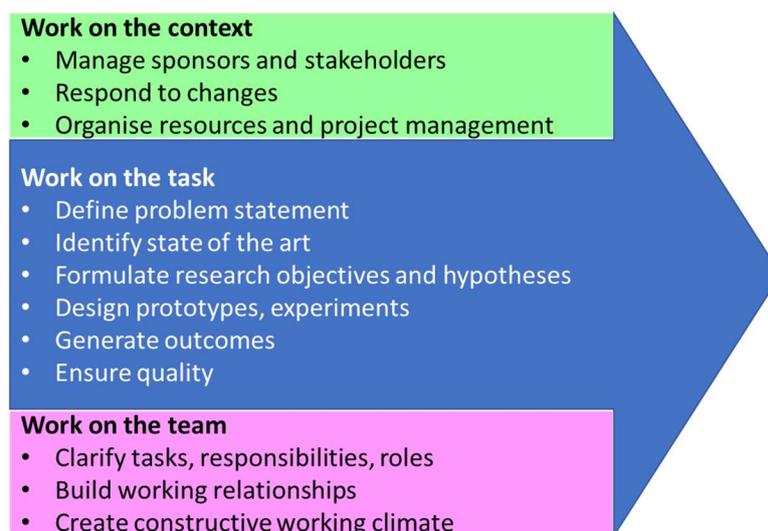


Figure 2: A TDW team will have to work on three levels simultaneously: on the task, on the context and on the team—where work on the context and team are instrumental to work on the task

Work on the task is always central. It addresses how the team handles the content of their work, the research goals. Work on the team addresses how the team organizes itself to work on the task. Work on the context addresses how the team creates and deals with the conditions around the team to work on the task. All three are indispensable, and their priority, duration and manifestation depend on the phase of the research and the situational circumstances. Most often, the team is working on task, team and context simultaneously.

A high performance TDW team understands the need to operate in all three areas because it realises that this is what it takes to reach the research goals. The team can distinguish task dynamics from team- or context dynamics, and the team members actively balance working on task, on team and on context. The team's maturity can be assessed by how easily the team switches between these kinds of work.

3.2 Work on the task: handling the content

Work on the task addresses how the team handles the content of their work. The TDW team takes ownership for directing the team's energy towards the task. The team members cultivate a heightened level of curiosity. This helps to acknowledge and integrate the differences in the team and make the differences productive. Also, the team builds habits that allow constructive communication patterns. These are characterised by little noise, high focus and openness.

3.2.1 Ownership for directing the team's energy toward the task

Typically, TDW members are persistently monitoring whether they are sufficiently focussed on the research goals. They regularly take a meta view on the team, and determine what the 'system' is telling them about how they are doing. On a regular basis, they deliberately ask themselves if their behaviour supports the task at hand. And they take immediate action when the team's energy and time is 'leaking' away and not going towards reaching the main goals. They readily explore what interventions are needed, and assume ownership for taking appropriate action.

A prevailing best practice for a mature TDW team, is that they apply a technique called 'centring' at the start of a team meeting. Using breath and concentration, centring directs the attention and energy of the team members and the team as a whole and focuses these towards the task. The exercise helps team members to be present in the moment and not distracted by events earlier that day or that are still pending. Centring typically takes 5-7 minutes.

3.2.2 Making differences productive

In a TDW team there is an abundance of differences between team members in both content and training. Differences come from disciplinary backgrounds as well as the contexts in which these disciplines operate. Other differences come from values, norms, personal and institutional preferences and histories. A big challenge for transdisciplinary teams is to recognize and acknowledge these differences. An even bigger hurdle however, is to make these differences *productive*.

Transdisciplinarity can arise when participating experts interact in open discussion and dialogue. Where they give equal weight to each perspective and relate these perspectives to each other. Instinctively, many of us oppose and challenge the other when we are confronted with a difference in perspective: we argue and try to convince the other, rather than explore and inquire. The successful transdisciplinary team cultivates its capacity to hold its differences. In order to be highly skilled at dealing with difference, a TDW team actively practices the mental skills that allow for

dealing with complexity and that improve their tolerance for the discomfort of ‘not knowing’. A good example of this, and critical for success, is cultivating curiosity.

3.2.3 Cultivating curiosity & exploring the edge of the unknown

Curiosity is the key to being open to differences and it requires a deep interest for not only one’s own mental models, but also that of others. Typical behaviour that you will see in a TDW team is that, as a rule of thumb, they adhere to self-imposed rules that allow them to stretch their curiosity further. For example, they might have a mutual agreement in a meeting that they practice their mental discipline for curiosity by only asking questions that they do not know the answer to. This may seem mundane, but try it 😊. It’s harder than you might think.

“I have no special talent. I am only passionately curious”

Albert Einstein

The TDW team pushes itself to venture out to the ‘edge of the unknown’; meaning that they invest time and energy in exploring ideas and realities of which they are utterly unsure what these will bring forth. They have no guarantees and they cannot predict what the consequences of their efforts will be.

A mature TDW team will need to go back and forth between exploring and explaining. Exploring entails linking intuitions, incomplete notions and undiscovered considerations to thoughts, thus entering new domains. Exploration can be set off against explanation: telling each other from current knowledge how things work.

3.2.4 Effective communication patterns

The communication pattern of a mature TDW team is characterized by low levels of ‘noise’. Noise is everything that distracts from focusing on the task. The mature TDW conversation is typically highly concentrated and critical, but also supportive. There are few contradictions (yes, but...) and there is low redundancy in the discussion because the team does not fall prey to repetition or echoing explanations.

What is said, is accessible for team members from other disciplinary backgrounds. In turn, what is said is not immediately challenged or criticized by other members in the team. On the receiving end, team members are willing to sit through the sensation of ‘not (yet) understanding’ what a team member is trying to explain. On the explaining end, team members actively work to use clear language and good examples to make their message accessible. In their conversation, the team noticeably steers clear from ambiguity and vagueness: Team members articulate their thoughts and ideas in straightforward, uncomplicated and unassuming language. They make an effort to stay away from suggestive framing or using leading questions.

In this way, the team members build on and expand each other’s ideas and thoughts, reflecting each other’s explorations. This makes it possible for them to allow differences in gradually.

3.3 Work on the team – organise and develop the team

Work on the team addresses how the team organizes itself to work on the task. The TDW team structures the work process and organises interventions that make the team more productive. They cultivate a habit of contextualising their work by taking a system’s perspective to see the bigger picture.

Working on the team comes from the understanding that not one of the individual researchers alone holds the key to answering the research questions. Work on the team is an explicit and conscious

decision to activate and build the ‘genius of the team’ and to make this genius productive. New ideas will need to emerge from the team through open, curious and critical dialogue and intense collaboration (as explicated in Chapter 3,2). Rarely, a newly formed research team is immediately capable of working in this way.

Therefore the team needs to organise itself to develop and practise the skills necessary for effective work together. A mature TDW team will systematically invest in organizing its structure, ways of working, skills and competencies to build and deepen the quality of interpersonal relationships and of the team as a whole. There is a determination to build the intellectual and emotional discipline needed to deal with the messiness of transdisciplinary work.

The team knows that this investment in time and energy will pay back manifold. It will manifest itself as: support for research decisions and a sense of shared responsibility, alignment on how to deal with criticism, clearer decision making, a climate where ‘exploring-what-you-not-yet-know’ is considered more valuable than explaining “how-things-are”, high levels of trust, the commitment to deliver the work that was agreed upon, and the capacity to bounce back from setbacks.

3.3.1 Structuring the work processes

The organisation of a TDW team first includes elements of structure and process necessary in all complex projects:

- Making agreements about deliverables and commitment
- Organise time, structure and formats for meetings
- Assign responsibilities and define roles
- Set working norms
- Organise decision making

In addition, the TDW team also organises interventions on an ongoing basis, to get better at making the differences in the team productive. These interventions are on the level of structure, process and skill. In the table below are some examples of interventions used to promote TDW (more examples are in chapter 6).

TDW Intervention	Description
State-Of-The-Art (SOTA) sessions	Team members explain the most important mental models of their discipline and introduce the team to the unresolved issues in their field.
Dialogue skills	Team members learn and practice skills to engage in an open dialogue and to create a constructive climate for dialogue
Motivation exploration	Team members share their personal motivation to working on their common task and link this motivation to the qualities and experience they have to bring into the team.
Scholastic method	Team members explore, question and expand their own core beliefs and most fundamental assumptions relevant to the research questions and hypotheses
Team dynamics	Team members work on understanding the dynamics in teams with large differences; mechanisms and paths of development. Practising tolerance for ‘messy team processes’.
Change framework Theory U	Team members travel through a ‘path’ towards innovation that first leads them through a phase of bringing together their knowledge and motivation, then exploring the underlying fundamental questions, then translating these into prototypes of solutions that are tested and refined.

Table 1: Some examples of possible interventions to promote TDW (more examples are in chapter 6)

3.3.2 Take a system's perspective

Even for mature TDW teams, there is a moment in complex projects when task work slows down and loses focus. Indicators are: meetings where no decisions are made, conversations that go around in circles, output that is not delivered or leadership that remains unclear about the goals. In order to move on, the mature TDW team will contextualise what is going on and try to see the bigger picture. They shift their perspective from the individual viewpoint, to what is happening in the system.

In TDW teams, the root cause of work slowing down can be the differences in perspectives. These can be so large that (subgroups of) researchers entrench themselves. They stop listening and start taking the differences in perspective personally. The team then typically loses flow and gets stuck.

A mature TDW team knows that the resolution to this is rarely found in debating the content of the task: more heated discussions or repetition of arguments will not bring the team back into flow. The conversation must shift to a different level: away from using convincing and persuading arguments, and towards using constructive, open and inquisitive communication patterns.

Using a systems-perspective helps the team to separate the facts from their feelings about the facts. A good way to take a systems-perspective is to conduct a so-called Force Field Analysis (see chapter 6 for details). This will help the team to openly and factually discuss what is preventing them from working effectively on the task. This perspective makes it easier to take things less personally, so team members are less likely to get held up in frustration, experience hurt feelings or use unproductive arguments.

When team members act on their insights from the force field analysis, the team can reclaim its energy that is now wasted on 'noise' and make it available for the task again.

3.4 Work on the context – create conditions for work

Work on the context addresses how the team creates the conditions to work on the task. All TDW team members take responsibility for managing the external context of their work.

In complex research programs sponsorship, funding, support or patronage often suddenly dwindle because of new developments. When this happens, the TDW team shifts focus from work on the task to what is influencing their ability to effectively work.

All members of a mature TDW team maintain functional relationships with the contexts where the work is done. Together, these relationships create the conditions that allow the team to work on the task and reach its goals. Every team member is responsible for managing a part of the team's context, including sponsors, knowledge partners, industry, citizens or end-users. This might be in contrast with common practise in 'traditional' research teams, where the task of shaping the context is considered the main responsibility of the project leader. In a mature TDW team, it is seen as a shared task. This is important in the context of a TDW team, because it is impossible for a project leader to have good connections in all the relevant disciplinary fields of his or her team.

The TDW team is constantly aware of how the conditions for success are created in the context. All members take ownership for taking an active role in shaping this context. This can range from mobilizing sponsors' support, lobbying to secure finances, arranging a tête-à-tête with a frontrunner in your field, to redesigning the physical workplace so that the working conditions for the team are ideal.

4. Systems Theory as a basis for Transdisciplinary work (TDW)

Systems Theory provides an excellent basis for understanding and organizing transdisciplinary work (TDW). Below we will present several key concepts from Systems Theory as it is used in Organization and Management Studies (Senge 1990; Argyris, 1999; Meadows 2009; Agazarian, 2004), e.g., in the form of *Theory U* (Scharmer 2007; Scharmer 2018), which we used as a framework to promote TDW—especially to facilitate the collaborative and iterative processes that it requires.

A *system* is a *mental construct* to understand and study a *set of things*, e.g., people, cells, molecules, that are interconnected in such a way that they produce their own pattern of behaviour, over time, to achieve a goal. Examples are: our digestive system, the Amsterdam transportation system, the TNO Organization as a whole, or indeed, a transdisciplinary team.

Systems have the following properties, which we will briefly and subsequently discuss below:

- A system has boundaries;
- A system is part of a hierarchy;
- A system is goal-directed;
- A system is in a dynamic equilibrium

A system has boundaries

A *system has boundaries*; boundaries that exist in space and time. Boundaries enable systems to organize their energy and information. Boundaries are fundamental to the survival, growth and development of human systems. Systems can open and close their boundaries, e.g., to let energy or information flow in or flow out. It is typically easier for a system to open its boundaries to things that are similar to the system itself, and less easy to things that are different. Integrating *similarities* requires no change and contributes to stability and *short-term* survival of the system, whereas integrating *differences* requires an effort—the latter is, however, needed for long-term survival of the system. Too much similarities and lack of differences can introduce rigidity, which threatens survival on the long run. A system needs to reorganize itself in order to absorb and integrate differences, e.g., new information.

Systems thinking can help to understand that the effort of *opening boundaries to differences* is both challenging *and* necessary for responsiveness, adaptation, growth and transformation—i.e. long-term survival. In other words: A system can only grow and transform by integrating differences—typically differences that originate in the system’s environment, and to which the system needs to respond. And yes, integrating differences requires energy, effort and can *temporarily* cause stress between the system and its environment and within the system.

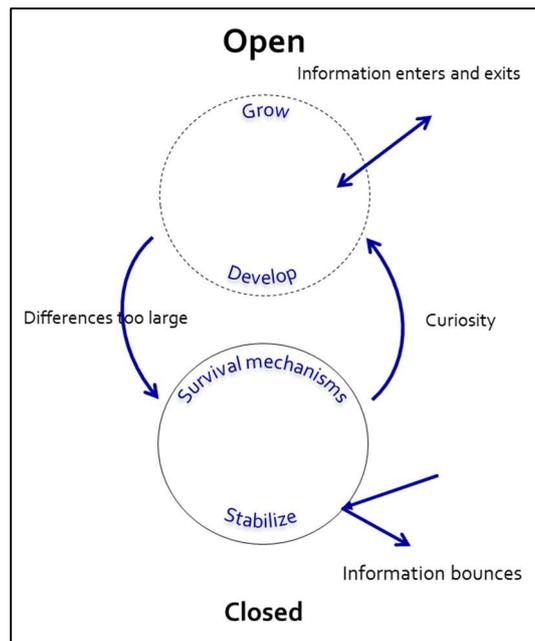


Figure 3: A system can open itself in order to let information enter and exit so that it can grow and develop. However, it will also need periods of closedness, in order to stabilize and survive.

A system is part of a hierarchy

A system is part of a hierarchy. Or, put differently: a system is connected to other systems; and these connections can be understood as hierarchical, so that the focal system can be defined by its place in this hierarchy. Very often, a system finds itself connected to two other systems: one 'above' itself and one 'below' itself. Their relationships have a 'give and take' quality (input, output). A system keeps itself stable by giving no more than it can afford, and taking no more than it can integrate.

For example, a transdisciplinary team will need to work on their research and innovation task, e.g., articulate research questions, conduct research, develop prototypes and conduct experiments. See figure 2, in two connected systems: the context and dynamics in this context, e.g., find sponsors, engage stakeholders and secure support for their project—so that they can work on their task; and the team and dynamics in the team, e.g., discuss and divide roles and responsibilities, and facilitate productive working relationships—so that they can work on their task.

If we focus on the transdisciplinary team as a system, we can recognize three subsystems within it: the individual members, the 'sub group', and the team as a whole. In practice, the 'sub group' is a key subsystem for regulating the dynamics within the team and thus for the functionality of the team as a whole. Here is an example: Suppose the team is engaged in a meeting and the discussion starts to become unproductive, e.g., it goes off-topic or it gets stuck into a loop of repetition. One team member may notice this. If she then speaks up, e.g., with a question or a remark about the need to stay productive, there will typically be several others who agree with her and who will express this and support the proposal to stay productive. This is the subgroup at work. This can, of course, also happen on the content level. One team member introduces a contrasting angle or topic, which others recognize and support.

Moreover, we will need to understand the hierarchies—or *relationships*—between behaviour, goals and context, and understand that behaviour needs to be 'functional'. Behaviour is 'functional' if it contributes to realizing specific goals that make sense in the given context. One can also reason the

other way around: The specific context influences (or sometime even determines) the goals and these goals then influence (or sometimes even determine) which behaviour is functional or not - functional. So, 'work on the task' is still central, overall—but at some phases in the project, the transdisciplinary team needs to carry out 'work on the context' or 'work on the team' in order to be able to continue 'work on the task' on the long run.

A system is goal-directed

A system is goal-directed. Systems have primary and secondary goals. The primary (or implicit) goals of any living human system are: first survival, then development, and then transformation. Development and transformation enable the system to increase its complexity, to become a more complex system. The secondary (or explicit) goals are to solve problems in the environment. Secondary goals are explicit and chosen by the system, e.g., serving the customer, making food for the guests, or conducting research. Ideally, the secondary goals determines the system's structure and behaviour. Taken together, these primary and secondary goals determine the system's actions. When the primary and secondary goals are aligned, all is well. However, when they conflict, the primary, implicit goals, e.g. of survival, will take precedence over the secondary, explicit goals, e.g. of conducting research.

A system is in a dynamic equilibrium

A system is in a dynamic equilibrium. Systems are dynamic, resilient and adaptive. We can see that all around us: systems can change, respond to events, and mend injuries. At any given moment, a system is in a dynamic equilibrium. Even when it seems to be at rest, it is in an dynamic equilibrium between forces that drive it to pursue its goal and forces that prevent it from realizing that same goal. The former, *driving forces*, promote growth and transformation, whereas the latter, *restraining forces*, ensure stability and survival. Such driving forces and restraining forces are present in any system.

These system properties have a direct implication on how transdisciplinary teams operate:

Systems properties	Implications
Boundaries	<ul style="list-style-type: none"> - Create conditions where boundaries are <ul style="list-style-type: none"> a) open enough to recognise and then integrate differences and b) closed enough to ensure stability. - Reduce noise in communication to increase permeability of the system boundary. - Develop personal and team habits that support exploring boundaries when differences arise (cultivate curiosity) - Build a working climate where reality testing is the norm - Grow tolerance for survival mechanisms in the team and members and work through them when they arise.
Hierarchy	<ul style="list-style-type: none"> - Match interventions to the appropriate level in the hierarchy. - Create a functional hierarchy related to the task and their phase of development of the team, including roles, responsibilities and tasks.
Goal-directed	<ul style="list-style-type: none"> - Define goals that are agreed and suitable to the context. - Enable the team and its members to engage in functional behaviour that directs its energy towards the goals.
Dynamic equilibrium	<ul style="list-style-type: none"> - Reduce the restraining forces inside and around the team system that keep it moving towards its goals.

5. What needs to be in place to make a TDW approach work?

In order for TDW teams to work successfully on the task, the context and the team, a few conditions need to be in place, see *Figure 4*. As explained in chapter 1, a transdisciplinary way of working is only necessary if the task (or problem to be solved) concerns a wicked problem.

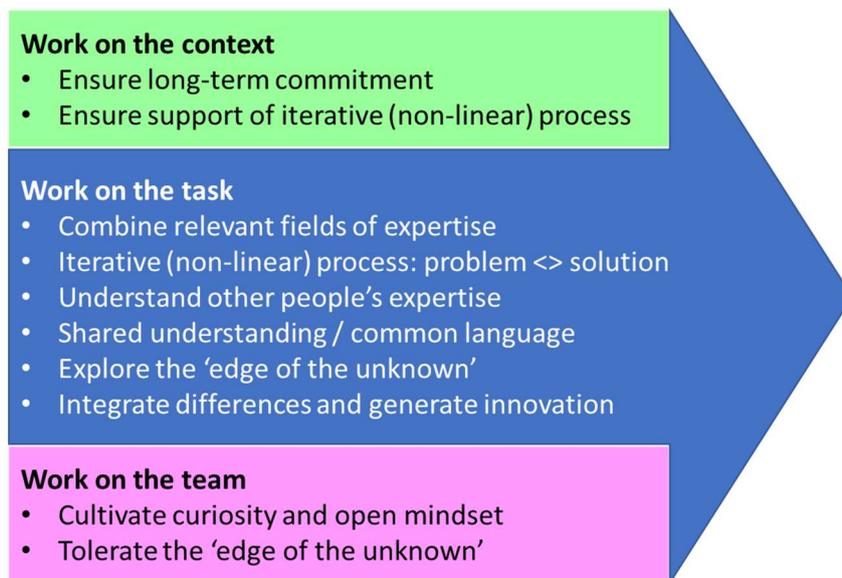


Figure 4: Conditions that promote successful TWD (illustrative; non-exhaustive)

Working on the task is then directly related to some of the conditions that need to be in place concerning the team and the context.

The team and team members must be willing to learn the mindset, habits and skills needed to work in a transdisciplinary way. The team members are asked to contribute not just to the task but also to building a team that can make differences productive and that can shape the team's context to create the conditions for success.

They must be curious, prepared and willing to learn to find new ways and invest time and effort in the development of the team, in order to be able to put a better focus on the task. Thus accepting that TDW may not directly result in papers or products. They must be able to listen to each other in a productive way in order to truly understand what someone is telling them, cultivate curiosity and maintain an open mindset (marked (2) in *Figure 4*), which will result in a shared understanding and common language that will directly help the team in working on the task. They need to be able to tolerate standing on the edge of the unknown (marked (3) in *Figure 4*), which may feel uncomfortable when not (yet) knowing the answers they are looking for. They must train the ability to recognize and explore this edge in order to use the differences in the team to their advantage, resulting in new ideas and solutions.

The context of the task is in the first place the organisation commissioning the research. This organisation must be equipped to handle the specific way of working within transdisciplinary projects. TDW almost per definition does not adhere to a linear line from start to finish, but rather, a TDW team goes through an iterative process (marked (1) in *Figure 4*), that requires the opportunity

to explore and work 'Spirographically'⁶ (see Figure 5). At first glance, or from a distance, this might appear unproductive and random, but following the same movements for some time makes new patterns visible.

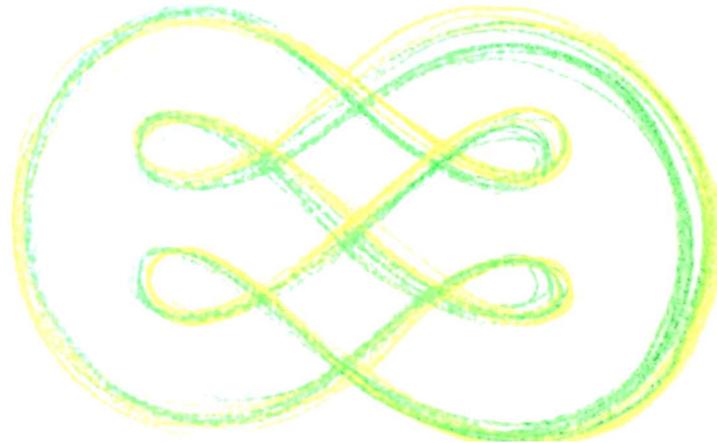


Figure 5: Working Spirographically may look like a team making random movements and going nowhere, but in fact, they are creating a unique pattern while repeating certain specific non-linear steps.

This means the organization needs to provide the team for its task:

- **Means** (time and budget): a wicked problem will unlikely be solved within a short timeframe, so a long term commitment must be given. Understandably this is not a free pass for a team to do whatever they want, and progress and deliverables will be communicated.
- **Understanding**: the nature of the process when dealing with a wicked problem, which will not follow a linear line from start to finish but rather follow a Spirographical pattern.
- **Support**: active sponsor(s) that are (also) capable of dealing with the edge of the unknown. They need to be able to be highly critical and challenge the team on the content of the problem and at the same time be lenient and tolerant on the process. The 'normal' project management tools and formats are often not suited for TDW. For example: a TWD-team will not be able to deliver its first deliverables soon after the start of a project, since they need to grow as a team and define the wicked problem before generating meaningful results.

Additionally the organization to which the TDW team belongs, needs to ensure the conditions for a constructive and safe working climate, these include a clear organizational structure, functional criteria for success and transparent processes for monitoring and evaluation of the progress.

⁶ We hereby coin the term spirographic work as a new concept that describes the 'non-linear' motion of which the pattern becomes evident only after a few iterations have been completed

6. Methods and Tools

Below, we present a range of methods and tools that can be used to facilitate Transdisciplinary work (TDW). They were used in the ERP Wise Policy Making and they can be used in any TDW. As an example, four of the tools have been described in more detail.

Please keep in mind that these methods and tools can be used effectively only if the teams works from the principles, regarding the three levels on which the project team members need to operate simultaneously (context / task / team), regarding 'functional behaviour' (what is 'functional' versus what is 'personal'), regarding opening and closing (in relation to information entering and exiting the system). In other words, for these methods and tools to be effective, there needs to be a basic understanding and motivation in the people involved—as was outlined in the previous sections.

Explanation of the tools: For each tool, the legenda indicates 1. the estimated time needed to apply the tool. 2. Need for facilitation- can the group apply the tools itself or is (expert) facilitation needed? 3. Team maturity – can a beginning TDW group use the tool, does it require amore mature team? 4. Intensity – does the tool challenge deeply held beliefs, or explores uncharted territory and therefore is likely to bring about tensions or is it a more analytical instrument?

Time:	 = 30 minutes
	 = 60 minutes
	 = 2-3 hours
Facilitator:	 = 'do it yourself'
	 = facilitator needed
	 = expert facilitator needed
Team maturity	 = from the start
	 = some experience needed
	 = for 'pros'
Intensity:	 = no or little (emotional) stress
	 = emotions possible or likely
	 = possibly emotionally intense

6.1. Force Field Analysis

Time: 
 Facilitator: 
 Team maturity: 
 Intensity: 
 Equipment: Flip-over or whiteboard

Driving forces 	Restraining forces 
...	...
...	...
...	...
...	...

Context

The transdisciplinary team is curious to understand its effectiveness: *What makes that we succeed or how come we failed?*

The team needs a tool to make sense of its experiences.

The force field analysis (pioneered by social psychologist Kurt Lewin) distinguishes *driving forces*, i.e. behaviours and conditions that *promote* movement towards a goal, and *restraining forces* that *hinder* movement.

From a systems development perspective, the team works on weakening the restraining forces to the flow of information and energy so that the driving forces will get more room.

Driving and restraining forces are present in any system. The current level of performance of the system is a state of equilibrium between the driving forces that encourage growth and transformation and the

restraining forces that ensure stability and survival.

Goal

Assess and understand the dynamics at a given moment, in a specific situation. And identify behaviours or factors for intervention that will allow growth and transformation (rather than stay in 'survival mode').

How to

Participants need a curious mindset, and they need to look for *observable behaviour*—instead of abstract concepts or opinions.

Make the force field together. Take turns. One person makes notes, for all to see. After a period of time, there will be some saturation, i.e. key issues have been identified.

After that, the participants can discuss ways to *promote the driving forces*, and ways to mitigate or *deal with the restraining forces*.

It is key to how to understand that any living system will naturally be inclined to grow and develop. Therefore, it is most effective to focus on promoting the driving forces (and deal with the restraining forces).

Note

Force fields depend on the goals and context of the team or individual: a limiting force in one context can be a driving force in another. That is why a force field is always created for a purpose and a context.

An example: In a brainstorming session, associative thinking is a driving force. When giving swimming lessons to toddlers, it will be a limiting force, because learning to swim requires a structured approach.

6.2. Scholastic Questions

Time: 
Facilitator: 
Team maturity: 
Intensity: 



Context

Curiosity is crucial for transdisciplinary work (TDW). Oftentimes, however, we find it hard to be genuinely curious. Standing in the way of curiosity are, e.g., our implicit assumptions and our usual ways of reasoning. These assumptions typically remain unexamined.

Asking questions can be a very productive way to promote curiosity. One particular style of asking questions is the Scholastic method.

This involves a pattern of repetitive asking questions – in pairs - about the opposite of what you are trying to achieve. This sounds disorienting. And it is.

Goal

The goal of Scholastic Questions is to examine and dissect one's current implicit assumptions and to cultivate curiosity. Examining and dissecting one's implicit assumptions will help to create a more curious disposition.

How to

This method can be practiced in pairs, say person A and person B. Together they discuss which assumption they want to examine and dissect. For example, in a project that aims to promote wisdom in policy making, a key assumption (worthy of further examination) would be: *We want to have more wisdom in policy making.* Then follow three rounds of repetitive questions and answers:

Person A then reverses this assumption and articulates it as a question to person B: *What would be good about not having wisdom in policy making?* Person B answers this question. Person A just listens and then asks the exact same question again. B answers. A listens and asks the question again. This continues a couple of times until some saturation is achieved (no more reasons to think of).

Person A then asks a new question to B, which articulates the original assumption as if it is already achieved today: *What wisdom is there already today in policy making?* Person B answers this question. Person A just listens and then asks the exact same question again. B answers. A listens and asks the question again. Etcetera until saturation.

Person A then asks a new question to B, making the question more experiential: *Where do you experience wisdom at this moment?* Person B answers this question. Etcetera until saturation.

Please note that the evaluation—by both participants—whether saturation has already been achieved is itself an exercise in being present, paying attention and being curious.

6.3. Powerful Questions

Time: 
Facilitator: 
Team maturity: 
Intensity: 



Context

During a presentation, your attention can drift away easily. Maybe you do not understand the person or you are not very interested in his or her presentation. Maybe your head is full of your own thoughts and associations.

For transdisciplinary work (TDW) however, it is crucial to be curious about other people and their contribution.

Goal

The goal of Powerful Questions is to focus on what the other person is saying and to cultivate curiosity. More specifically, its goal is to promote the effective absorbing of new knowledge, the effective integration of new knowledge, and the productive combination of different pieces of knowledge.

How to

This tool is used in three consecutive stages:

1. during the presentation, while listening, to absorb new knowledge;
2. after the presentation, while discussing in pairs, to integrate new knowledge;
3. and in a plenary dialogue, to combine different pieces of knowledge.

During the presentation you place yourself as much as possible in the feet of the person talking. What is his or her worldview? What are his or her overarching beliefs and aspirations? You try to see what they see in that light. You cognitively empathize with them. During this listening, you will have questions. You write these down. Or your curiosity will be sparked. Make notes. It is key that you do not interrupt the speaker.

After the presentation, you make pairs and these pairs discuss what they heard and the questions and curiosity it did raise in them. Person A shares while person B just listens. When A is done sharing, B can ask several curious questions. They refrain from 'knowing it better', explaining or convincing. Then they switch roles. Articulating their questions and listening to the other's questions helps to integrate new knowledge and spark curiosity.

Then follows a plenary dialogue. Participants can only ask Powerful Questions: open questions; questions that emerge from curiosity; questions that open opportunities regarding the task at hand and the task's context—these are indeed functional.

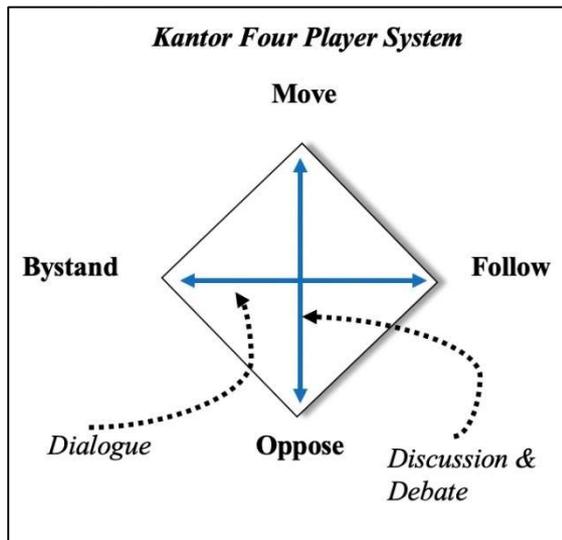
So-called 'questions' that are meant to present one's own knowledge or that critique the other are not functional.

Note

You can track the growing level of curiosity in a project team. You can observe, e.g., the following: asking open questions, active body language, taking time to listen, tolerating moments of silence, and engagement.

6.4. Kantor's Four Player Model

Time: 
 Facilitator: 
 Team maturity: 
 Intensity: 



Context

Transdisciplinary work (TDW) requires the integration of different fields of knowledge. It also requires a pattern that alternates between *opening-up and absorbing* and *generating new knowledge, and closing-down and integrating and solidifying* knowledge.

TDW requires of the people involved that they can alternate between opening-up and closing-down. At one moment they need to focus on *exploration and concepts*, whereas at another moment they need to focus on producing *tangible results*.

Goal

Kantor's Four Player Model can help with making these different movements.

Its goal is to help the people involved to recognize, of themselves and of the others, which *move they are making at any given moment*. Making this more explicit will make

the team dynamics much more functional—that is: less personal.

If A understands that B wants to propose a new solution for an urgent problem ('Move'), then A can better understand that this is a functional move—not a personal move towards some personal gain. Or if C understands that D critiques C's *remark* ('Oppose') (*not* C himself), then C can understand that this is functional move—not a personal move against C or against one of the others.

How to

There are four possible *conversational actions*:

- **Move:** When someone makes a move they are initiating an action. They carry, at least for the moment, the focus of the conversation.
- **Follow:** A person might agree and want to support what was said. He says so, and symbolically becomes close to the first person.
- **Oppose:** Another person may think 'there is something not quite right with this'. She steps in and challenges what they have said.
- **Bystand:** A fourth person has observed the entire situation and has the advantage of having one foot in and one foot out of the circumstance; he describes his perspective of what he has seen and heard.

A well-functioning team dialogues using these actions in balanced and fluid sequences. All four actions should be common and seen as valuable, and individuals are fluid in their ability to take on different roles.

The team can learn to articulate these roles, comparable to Edward De Bono's Thinking Hats. A first time, it can be worthwhile to make the moves totally explicit, e.g., by putting the diamond shape on the floor and actually walking around on it. One can then also experiment with making moves that one would normally do less often.

6.5. Deep Listening (Stone)

Time:	
Facilitator:	
Expertise:	
Team maturity:	
Equipment:	Several pebbles



Context

In a transdisciplinary team, differences are big: members operate from different mental models, they even use different words to describe similar phenomena. Noise and confusion are around the corner. To create new knowledge, the team needs to learn to recognise, appreciate and integrate its differences. The practices of listening and mirroring dealing with differences.

Goal

Increase the skill of dealing with differences in a conversation.

Experience the benefit of intense listening and mirroring the other to make sure that information and energy come across.

Enabling the team to explore on the edge of the unknown, rather than explain to each other what it knows already

How to

To train this method: Person A holds a stone and speaks. Person B listens. After A finished speaking, B paraphrases what A said. It is important to avoid two pitfalls: literally parroting what A said; and making interpretations of what A said. If A feels really understood by B, then A hands the stone to B. If, however, A does not feel understood by B, A repeats that part of his/her message, and gives B another chance to paraphrase. B tries again. This continues until A feels understood. It is key for A *not* make compromises. A gives the stone to B, and it is B's turn to speak, and A's turn to listen.

To apply this method: In a team-setting, everybody listens to A, and the one who wants to speak becomes B. One can only speak after first mirroring what the previous speakers did say. One can do this with or without stone. The goal is to first establish a connection—and demonstrate understanding—and only then add new ideas. Only after the summary (and receiving the stone, if the stone is used) the new person can speak.

Please note that one needs to be open and curious and suspend one's voice of judgement ('open mind'), voice of cynicism ('open heart') and voice of fear ('open will') (Scharmer).

Other methods, which we did apply but did not yet document properly:

- 6.6. Centering
- 6.7. Your own voice
- 6.8. Sensing Journey
- 6.9. Stakeholder Interviews
- 6.10. Dialogue Interviews
- 6.11. Systemic Modelling
- 6.12. Prototyping
- 6.13. Storytelling
- 6.14. Spirograp

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Appendix I: illustration of a 2-day program of TDW in the ERP Wise Policy Making ‘Difference Days’



“The single essential process by which living human systems develop from simple to complex is by discriminating and integrating differences.”

(Agazarian, 2004)

Context van Programma ‘Difference Days’ 11-12 November 2019

Transdisciplinair onderzoek genereert nieuwe kennis tussen disciplines. Dat noodzaakt tot het herkennen, erkennen en integreren van overeenkomsten én vooral verschillen’. De grote uitdaging in ons onderzoek is het productief maken van verschillen.

Overeenkomsten zijn makkelijk en verschillen zijn lastig. We hebben verschillen op veel lagen: tussen mental models, disciplines, persoonlijkheden, werkstijlen, kleding en eten. De centrale veronderstelling is dat wanneer een transdisciplinair team verschillen vakkundig kan herkennen en integreren, het niet alleen zal overleven, maar ook ontwikkelen en transformeren.

De ambitie als transdisciplinair team – profs worden in het integreren van verschillen

Wanneer de grenzen van het team en van de teamleden adequaat doorlatend zijn, kan het team verschillen benutten als hulpbron om oplossingen te vinden die adequater, meer toegesneden, innovatiever en meer afgestemd zijn op de complexiteit van het probleem. Het team zal met meer gemak in de richting van het doel gaan.

Jaar 1. Verkennen; Jaar 2. Focus, leveren & verkennen combineren

In jaar 1 stond het onderzoek in het teken van verkennen: verhelderen en aanscherpen van de vraagstelling, SOTA van de disciplines, samenwerkingsrelaties opbouwen in het team en in subgroepen, managen van de context, produceren onder hoge druk.

In jaar 2 begint ook een volgende fase: verkennen combineren met leveren. In jaar 2 komt er meer focus. De stip op de horizon is duidelijker. De energie en aandacht kan meer geconcentreerd zijn. De aard van de samenwerking zal ook veranderen: in subteams ontstaat meer autonomie. Uitdagingen zijn onder meer:

- Hoe houden we overzicht?
- Welke balans vinden we tussen decentraal (in subgroepen) en plenair?
- Hoe werken we in onze subgroep samen?
- Hoe afstemmen tussen subgroepen - Hoe zorgen dat subteams gericht blijven op zowel hun eigen doel als op de stip op de horizon?

Een deel van deze uitdagingen is te ondervangen met een -lineaire- structuur:

- helder geformuleerde uitkomsten en criteria voor succes,
- overlegmomenten en milestones,
- verdeling van rollen, taken en verantwoordelijkheden.

Het kernprincipe is hier: hoe kunnen we nét genoeg structuur maken? Te veel structuur fixeert. Het maakt afhankelijk en heeft als bijeffect vaak reactiviteit: meer vertrouwen op de structuur en minder op eigenaarschap, initiatief en nieuwsgierigheid. En de laatste zijn hard nodig: het werk is nog steeds geen routine. In de werkpakketten gaan de onderzoekers ook dit jaar weer samen de rand van het onbekende opzoeken. Entegelijkertijd dient er geleverd te worden. Uitdagingen zijn daarbij:

- Verschillen voor jezelf en het team laten werken -
- Schakelvermogen: van verkennen naar leveren en terug.
- Eigen initiatief nemen en houden.
- Nieuwsgierigheid cultiveren.
- Functioneel vertragen.
- Bewustzijn van de groep en van jezelf.
- Focus op de taak en dingen niet persoonlijk nemen.
- Eigenaarschap nemen en houden

Dit vraagt een niet-lineaire werkwijze. Het vereist een verder groeiende vaardigheid in het herkennen, erkennen en integreren van verschillen. Het vraagt om te oefenen met werkwijzen in de subgroepen die de onderzoekers en het team als geheel helpen om scherp te krijgen of hun eigen gedrag en dat van de groep als geheel functioneel zijn voor het bereiken van het bovenliggende doel.

Programma dag 1

Tijd	Activiteit
8:00 – 10:00	Inloop en/of zelfstandig werken
09:00 – 09:50	Prepare meeting room
10:00 – 10:20	Opening & welkom A. Nieuwe leden B. Centreren C. Mededelingen D. Succescriteria
10:20 – 10:50	Kaart & Oriëntatie – waar zijn we naar onderweg? Wat vraagt transdisciplinair werken en wat kan het opleveren? <u>Doel</u> Context bieden voor transdisciplinair werken en opfrissen van ERP-methodiek en kader
10:50 – 11:30	Verwelkomen van verschillen, herijken van je eigen stem – <u>Doelen</u> – (Her-)ijken van je eigen motivatie in het ERP – (Her-)Vinden van een krachtig symbool – Uitspreken welke stem je inbrengt in het ERP
11:30 – 12:30	Waarderen van Vooruitgang – reflecteren op 2019 <u>Doelen</u> – Bepalen van de voortgang als team dat transdisciplinair leert werken – Vaststellen van de lessen voor jezelf en als team

Tijd	Activiteit
	<ul style="list-style-type: none"> – Bepalen van een ieders rand (edge) om transdisciplinair te leren werken in 2020. – Oefenen met het kerntool forcefield analysis
12.30 – 13.30	Lunch
13.30 – 15.00	Itereren – voortgang maken terwijl je niet weet waar je naartoe gaat <u>Doelen</u> <ul style="list-style-type: none"> – De essentie en waarde van itereren begrijpen – Verkennen van de uitdaging van itereren en deze koppelen aan je eigen stijl van omgaan met het onzekerheid – Inzicht in de condities krijgen waaronder itereren voor jezelf en voor de groep kunnen werken – Oefenen met een techniek voor het verkennen en integreren van verschillen.
15:00 – 17:30	Masterclass - presteren onder druk; verschillen in verwachting hanteren <u>Doelen</u> <ul style="list-style-type: none"> – Uitbreiden van je instrumentarium om verschillen te hanteren – Verkennen van het effect van druk op je systeem: lichaam en geest – Druk leren reguleren door je lichaam te benutten
17:30 – 18:00	Leren van de MasterClass
18:00 – 20:00	Uit eten

Programma dag 2

10:00 – 10:20	Opening & welkom (JS) Centreren Mededelingen Dag 2 plus agenda
10:15 – 11:45	Casus – Urban Mobility <u>Doelen</u> <ul style="list-style-type: none"> – Oplijnen van de groep – context, problematiek en dynamiek – Kader neerzetten voor een gedeeld beeld van de casus – Doorkijk naar link Wise Policy en Use-case – Info verzamelen: wat is nuttig aan deze Use-case voor mijn onderdeel van het onderzoek? Wat dekt het niet af?
10:45 – 11:00	Koffiepauze
11:00 – 12:30	Opzet programma 2020 <u>Doelen</u> <ul style="list-style-type: none"> – Transparent maken werkwijze en intentie voorbereidingsgroep

	<ul style="list-style-type: none"> – Delen van de opzet en werkwijze ERP 2020: structuur, rollen, inhoud, werkwijze – Wise Input van de groep verzamelen
12:30 – 13:30	Lunch
13:30 – 13:45	Relevantie & noodzaak Use-Case (15 min.) <u>Doel</u> Toetsen relevantie en aansluiting/ open plekken use case
13:45 – 15:00	Innoveren in de praktijk – verdiepen vs. Leveren <u>Doelen</u> <ul style="list-style-type: none"> – Fundamentele spanning/ paradox onderzoeken tussen verdiepen en leveren – Oefenen met een techniek om deze spanning te hanteren
15:15 – 15.30	Koffie
15:30 – 16:30	2020 in de praktijk – plannen, afspraken <u>Doelen</u> <ul style="list-style-type: none"> – Vertalen van plannen naar praktijk – Agenda's blokkeren voor ze vol lopen – Losse eindjes en to do's verzamelen en activiteiten verdelen
16:30 – 17:00	Afronden en huiswaarts