Building a knowledge infrastructure for Transformative Innovation Policy (TIP). An analytical approach based on the experimental TIP conference 2022

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ABSTRACT

Tackling social and environmental challenges requires communities that can create, integrate, use, and contextualise diverse knowledges. The Transformative Innovation Policy (TIP) seeks to respond to these challenges through collective action enabled by experimental and inclusive approaches. This paper focuses on examining the kind of knowledges, structures and practices required to build a knowledge infrastructure (KI) for TIP, taking the TIP Conference 2022 as a case study. The conference aimed at building a sustainable and inclusive KI for systemic transformation pathways, providing the basis for a TIP KI framework. The framework includes tangible and intangible infrastructures that support broadening and deepening networks, learning, unlearning, and aligning visions. These are the constituent elements to build communities of practice that can integrate knowledge towards transformation pathways. Furthermore, the paper explores how conferences can contribute towards transdisciplinary and action-oriented research as part of their developing strategies.

1. Introduction

Tackling climate change through a socially just transition to a cleaner, safer and peaceful world is now a global aim. Such a transition is impossible without innovation, new (types of) knowledge creation, and systems change. Transformative Innovation Policy (TIP) is an emerging research and action field aiming for the systems change required to address the UN's 17 Sustainable Development Goals (SDGs). TIP addresses social and environmental challenges through an experimental, inclusive, and participatory approach in line with the sustainability transitions literature (Schot and Steinmueller, 2018). Such an endeavour requires collective knowledge gathered through shared infrastructures that allow negotiation, merging, and integration, with a range of convergence (allowing diversity of knowledges) to advance in transition pathways and transformative actions (Lukkarinen et al., 2023). The alignment of visions contributes to the coherence of knowledge across varied academic and non-academic communities that usually have siloed and fragmented resources, and practices (Monstadt

et al., 2022). Nevertheless, the attributes and challenges of knowledge integration in an ever-expanding research community are hardly discussed (Preuß et al., 2021). We argue that we need to enhance the knowledge creation and integration processes related to sustainability to achieve systems change and the SDGs.

Creating actionable knowledge necessitates collaboration among a diverse array of persons with varying perspectives, expertise, interests, and objectives. This collaboration can be effectively facilitated by the presence of knowledge infrastructures, enabling the formation of constellations of actors who share common goals and objectives. Knowledge infrastructures (KI) are sense-making platforms that contain specific assets (such as books, software, hardware, virtual platforms, forums, etc.), means towards individual and collective capacity building (seminars, organisational units, specific initiatives, etc.), and purposes (justice, sustainability, regional development, etc.) translated into actions in the community knowledge domain (Caniglia et al., 2021; Huddleston et al., 2022). Edwards (2010) defines knowledge infrastructures as robust networks of people, artefacts, and institutions that generate,

share, and maintain specific knowledge about the human and natural worlds. In that sense, KIs favour the connection of otherwise fragmented communities and stewards to share knowledge over time and across the boundaries of stakeholder organizations (Pearsall et al., 2022).

In this paper, we delve into the role of a specific experimental environment in shaping the components of a KI for TIP. Specifically, we focus on three key aspects: the types of existing knowledge, the tangible and intangible infrastructures, and the specific practices vital for constructing such a KI. We propose a framework for conceptualising and building a KI using the design and results of TIP Conference 2022 as our case study. In that sense, our framework emerges retrospectively from the analysis of the Conference.

The 2022 TIP conference took place between 17th and 21st January 2022, with the aim of building a sustainable and inclusive KI for TIP. Grounded in a formative evaluation approach to TIP (Molas-Gallart et al., 2021), the organisers established a Theory of Change (ToC) to inform the conference's design and evaluation. This ToC articulated key assumptions underlying the conference, namely, that a sustainable KI for TIP could be advanced through the creation of a digital experimental space aimed at facilitating knowledge alignment and learning, as well as fostering communities of practice by expanding and enriching professional networks. Learning and unlearning were critical processes for both elements.

Since the KI for TIP framework emerges from the analysis of our case study, the paper has a structure reflecting the inductive process we followed. In Section 2, we provide an in-depth description of our case study, including the conference's Theory of Change and the monitoring, evaluation, and learning plan. Section 3 engages in a comprehensive discussion regarding how the results of the conference contribute to three pivotal components of a KI for TIP. Moving on to Section 4, we introduce our KI framework for TIP. Lastly, Section 5 offers primary conclusions and broader implications from our findings.

2. The TIP Conference 2022 as an experimental engagement

The development of TIP has been a collaborative effort among various groups of researchers, practitioners, and policymakers. In 2018, the innovation and transition academic networks Eu-SPRI,[1] Globelics,[2] STRN,[3] and TIPC[4] researchers initiated a series of inter-network dialogues. These dialogues reinforced the importance of building networks and addressing the complex challenges of systems transformation. Drawing on interdisciplinary research, the first TIP conference was launched in November 2019. The conference aimed to advance a global research agenda for TIP, featuring over 60 projects from a diverse set of actors. At that point, TIPC had been running for two years, and there was evidence that TIPC could become a temporary space for integrating knowledge in transdisciplinary communities of practice. The conference results were organised and further elaborated in a TIP research agenda, which included themes on conceptualisation, actors, contexts, and operationalisation of TIP (Ghosh and Torrens, 2020).

In January 2022, the TIP community convened its second conference organised by TIPC and Eu-SPRI, seeking to lay the foundation for a robust knowledge infrastructure dedicated to TIP. The conference was delivered in a virtual format that not only broadened accessibility and participation but also harmonised perfectly with the community's core values of inclusivity and collaborative engagement.

There was a wide variety of participants related to location and

background, including 884 delegates from 5 continents and 71 countries, as seen in Table 1.

The TIP Conference 2022 served as a temporary space for exploring unconventional conference formats, as was expressed in the call for participation.[5] The invitation was extended to early career and senior researchers, practitioners and policymakers, industry practitioners, development agencies, grassroots innovators and entrepreneurs, NGOs, media, and investors. The organisers called for initiatives in different stages of development, also inviting participants to use the conference space to develop ideas into experimental projects by making use of the digital platforms provided. Organisers encouraged the presentation of collaborative contributions in different formats, such as panels, pitching transformations, demonstrators of ongoing transformative initiatives, and collaborative exercises to gather collective intelligence using interactive methods. The option to propose other formats was also opened. The conference did not ask for a registration fee to avoid access barriers and make the space open and available to anyone interested. Expressions of interest to present at the conference included a description of the team, aims, objectives, methods, and results (if applicable) of the initiative, format for delivering the session, and personal aims to be part of the conference.

Drawing inspiration from the socio-technical transitions literature, which posits that groundbreaking innovations often arise from experimental practices among a diverse range of actors in niche spaces (Smith and Raven, 2012), the TIP conference was conceived as a proto-niche where the organisers could test new approaches to the theory and practice of TIP, particularly to: the conceptualisation of innovation for transformative change, the role of experimentation, from experimentation to mainstreaming and embedding, the role of landscape events, policy and governance for transformative change, inclusion and role of transformative actors, geography of transformation pathways, evaluation of TIPs, and the definition and use of knowledge infrastructures for transformation. Furthermore, the conference acted as a shielded space, allowing actors to develop alternative practices within their organisations to come together, break isolation, build networks, learn from the community, and navigate different expectations. In other words, the conference was designed to foster the creation and nurturing of a niche, as conceptualised in transitions theory (Ghosh et al., 2021).

2.1. Conference theory of change

The conference organisers placed a strong emphasis on experimentation as a way to challenge traditional approaches to knowledge

Table 1
Location and Background Information.

Continent	Number of Participants (%)
Europe	460 (52.04 %)
South America	202 (22.85 %)
Africa	101 (11.42 %)
Asia	80 (9.25 %)
North America	30 (3.39 %)
Australia-Oceania	9 (1.05 %)

Background	Number of Participants (%)
Researcher and Lecturers	422 (47.7 %)
Students	128 (14.5 %)
Public Sector Practitioners	90 (10.2 %)
Policymakers	74 (8.4 %)
Non-profit Sector Practitioners	54 (6.1 %)
Private Sector Practitioners	42 (4.8 %)
Other	71 (8.3 %)

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production and dissemination. In addition to the usual scientific and executive committees, they formed an experimentation committee (EC) tasked with designing, implementing, and evaluating innovative strategies throughout the conference. To guide their efforts, the committee developed a ToC for the conference, using the TIPC approach to evaluation (Molas-Gallart et al., 2021).

The ToC defined a long-term goal, outcomes, outputs, and activities, outlining associated assumptions for each outcome. In TIPC's methodology, an "outcome" refers to changes in people, organisations, and institutions, which also involves the related processes to get there. Outputs are concrete results obtained by a series of intended tasks or activities. The ToC was used to design the conference and its evaluation strategy.

A representation of the conference Theory of Change can be seen in Fig. 1.

The four TOs for assessing the conference's contribution to building a KI for TIP were: 1) broaden and deepen the network of actors pursuing transformative initiatives; 2) learning and unlearning among
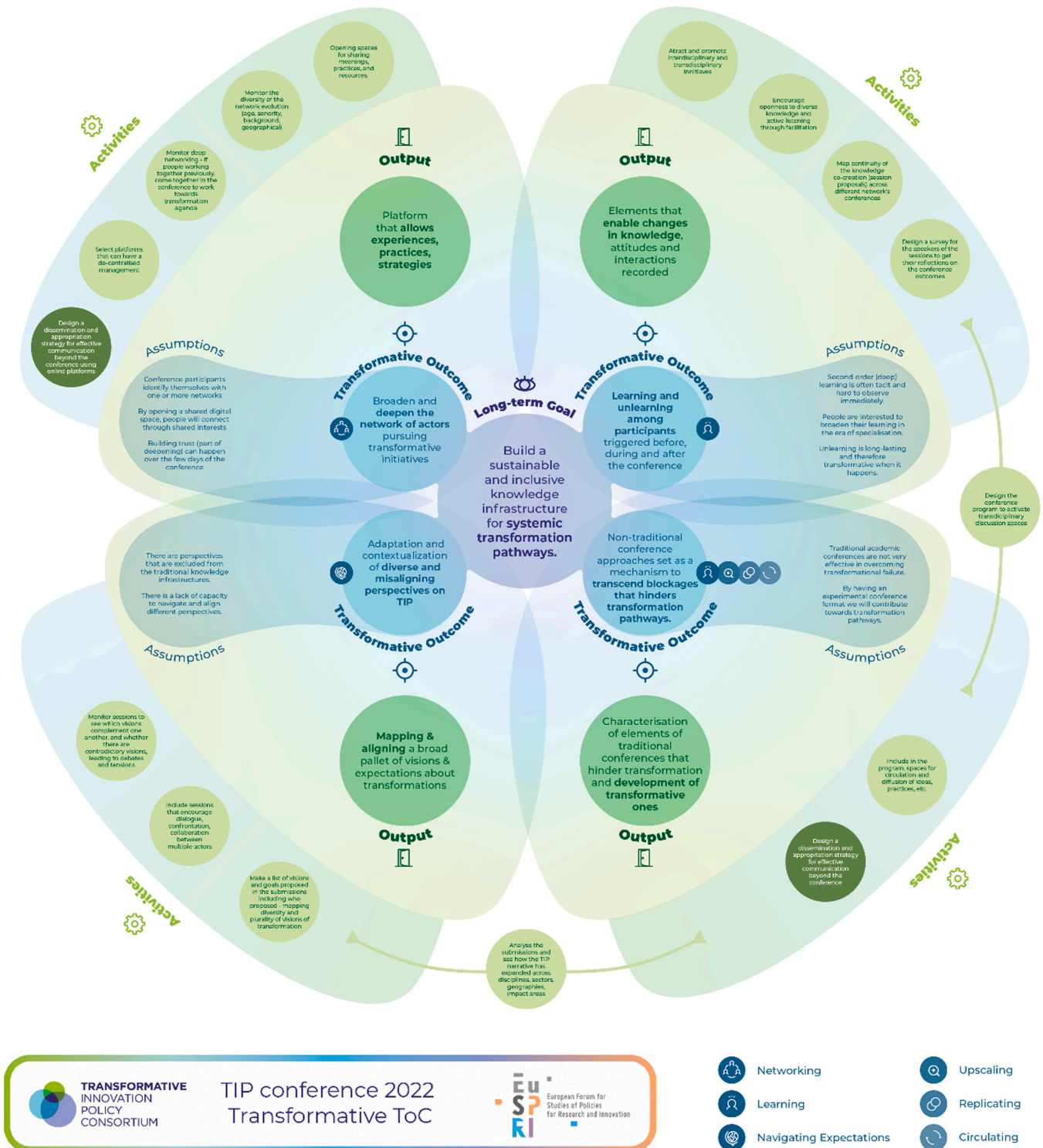

Fig. 1. TIP conference 2022 Transformative Theory of Change.

participants triggered before, during, and after the conference; 3) mapping and aligning a broad pallet of visions and expectations about transformations; and 4) non-traditional conference approaches to transcend blockages that hinders transformation pathways.

The definition of the four outcomes was rooted in transitions theory. Transitions, by their very nature, are intricate, multi-actor processes that demand deliberate strategies to facilitate the expansion of social networks comprising a diverse spectrum of actors working collaboratively, deepening their actions into concrete alternative solutions. Within these networks, actors engage in a dynamic exchange of knowledge, skills, and capabilities, marking what is termed "first-order learning." Furthermore, these interactions lead to critical reflection, adaptation, and the cultivation of new visions and perspectives that challenge established worldviews, a phenomenon referred to as "second-order learning" (Ghosh et al., 2021; Van Mierlo and Beers, 2020).

These processes embody a dynamic interplay of diverse visions and expectations concerning the manifold possibilities inherent in various change pathways. This diversity is essential for the exploration and refinement of various alternatives, ultimately culminating in the convergence toward desirable transitions (Raven et al., 2010; Sengers et al., 2019).

2.2. Monitoring, evaluation and learning (MEL) plan

Guided by the ToC, the MEL plan developed practical actions before, during, and after the conference for each outcome.

A summary of the data collection methods used for the MEL plan can be seen in Table 2. The number of survey respondents reflects the response rate filled in voluntarily. Before the conference, emails were sent to all delegates asking them to complete a survey to gather their interest in attending the different sessions and their expectations related to the conference. During the conference, emails were sent daily to all registered participants asking them to have an asynchronous reflection on their learning process by commenting on their experience in the sessions about changing their assumptions, questioning their knowledge, how comfortable they felt expressing their critical opinions, and their overall impressions of the sessions. Likewise, each day after the end of all sessions, an email was sent to the session owners to share their observations on the level of interest of the participants, the depth of the discussions, the creation of new ideas and definitions, the quality of listening to each other's ideas, participation of different backgrounds and knowledge, if there were contradictory visions and their ideas on how to advance on their initiative after the conference. Concerning the interviews, the experimentation committee looked into the most active participants in the conference and selected a sample of them with different levels of seniority, gender, background, areas of specialisation

Table 2
Data collection methods of the MEL plan.

Method	Observations
Surveys	
Pre-conference	16 respondents
Mid-conference	11 respondents
Post-conference	38 respondents
Speakers survey	33 respondents
In-depth interviews	8 interviews with gender, seniority, age, role, location (global south and global north) balance. Interviewees selected also by their participation in at least 3 of the 5 conference days.
Observers report	11 observers
Mini blogs	Made directly by 4 of the interviewees. Maximum 500 words providing reflections about their experience during and after the conference.
Initiatives submissions analysis	40 accepted submissions
Digital platform metrics	Metrics from registration, sessions during the conference, networking tables, and networking tools of the platform.
Network analysis	Network map using specialised software

Table 3
Conference platform feature details (recorded features used in data analysis).

Content	Action	Intended purpose of engagement
Announcements/ Overview/ Programme/ Donations/ Speakers/ Demonstrations/ Platform Guide/ Guided Reflection/ Post session survey/ Privacy Statement	Viewed/Clicked	Getting participants used to the digital platform
Wall	Clicked/Liked/ Commented a Post	Getting participants to socialise and interact with other participants in a written format
Networking Table	Joined a Room/ Sent a Message	Getting participants to interact in a verbal video format
Pre-conference/Conference game	Clicked/ Completed challenge	Adding an incentive for engaging with the conference and providing a fun, relaxing environment
Let's chat on Slack!	Clicked	Offering participants an option to carry on a long-term continuous engagement with the community beyond the existing short-term digital space for the conference

and geographical location to gather a variety of visions.

Regarding the interpretation of the findings, we want to explicitly state that the number of responses in the data represents only a fraction of the total participants, especially concerning the surveys, given that these were voluntary to fill in. This leads to some limitations regarding a valid generalised statistical interpretation of the survey results, considering representativeness, increased variability, and risk of bias. To counteract this, the survey results have been triangulated with other data sources, such as the observers' reports, interviews, and data collected from the digital platform. Together, they provided valuable qualitative insights into critical elements required to build a TIP knowledge infrastructure.

For the first outcome (O1), a broader and deeper network of actors pursuing transformative initiatives, a baseline of the speakers' network who presented initiatives and were part of the central panels, was created. During the conference, the organisers gathered data on potential new networks through 1) the digital conference platform that had a feature to start writing, voice and video chats among participants; 2) networking-themed tables, which were dedicated spaces set at specific times every day of the conference, without any other sessions happening concurrently. The purpose of these tables was to encourage networking of people interested in similar topics; 3) Analysis of chat interactions in the parallel sessions among delegates and speakers.

Surveys for delegates and speakers were sent during the conference. The purpose was to identify potential network expansion as a conference product. After the conference, the organisers applied a post-conference survey which included questions related to broadening the current network as an effect of the participation of the delegates in the conference (broadening networks) and inquired if the conference helped to mobilise actions within current or expanded networks (deepening networks). In-depth interviews and observation of the different conference spaces also provided data for O1.

Two guidelines (for session convenors and observers) were developed to foster learning and unlearning (or the process of questioning views, practices, values and routines leading to changes in behaviours) triggered before, during, and after the conference (O2). For session conveners, the guidelines encouraged openness to diverse knowledges and active listening through facilitation; for a group of observers that joined each session, the guidelines were directed to capture know-what, know-how, and know-why or first-order learning and deeper reflections

and discussions leading to second-order learning among the sessions participants. There were also, on each day of the conference, short sessions for 'live' reflection and learning to explore the delegates' perceptions, reflections, and experiences related to the conference outcomes. On the last day of the conference, results from the series of sessions were presented in a plenary session to explore whether the conference supported the creation of a sustainable KI, and to help identify blockages to transformation pathways. After the conference, questions related to the expansion of knowledge integration, strengthening of interactions, and change in attitudes were included in the post-conference survey. The findings from the survey and observations related to learning reported by the observers contributed data for O2.

To monitor the third outcome O3, diverse and misaligning visions/ perspectives that can be adapted and contextualised, delegates expressed their expectations and visions about transformation before the conference through a survey. There was also an analysis of the initiatives submitted and accepted at the conference to explore the diversity and plurality of the visions and perspectives about the meaning of transformation. The programme design intentionally put together in the sessions a diverse range of actors from academia, policy, NGOs, and mixed organisations to encourage generative dialogues. The speaker's guide encouraged openness and disposition to listen to others' points of view and put forward their ideas for discussion. The observers tracked how diverse and open the sessions' discussions were. Lastly, the post-conference survey and in-depth interviews included questions such as participants' disposal to participate, express their points of view, debate perspectives, and generate reflections related to the meaning of transformation in different contexts and socio-technical systems.

Lastly, the outcome of setting non-traditional conference approaches as a mechanism to transcend blockages that hinder transformation pathways (O4) was monitored by the compounded effort from the other three outcomes. The conference approach was non-traditional (i.e. different from modern (online) academic conferences) in several ways. The conference was set up to deliberately encourage not just the transmission of scientific information but further reflection by participants on how the conference themes resonated with their work. In this way, the conference aimed to stimulate second-order learning processes in participants (in which participants question their conceptions and norms). Through a pre-conference process, a theory of change for the conference was developed; the theory of change provided the framework for the conference design. Besides traditional knowledge-sharing sessions with pre-defined speakers and a listening audience, the conference design included daily sessions for interactions, reflection, and networking, as well as digital communication channels for participants (opened pre-conference and maintained post-conference). The experimentation committee had a plenary session to explain the conference design, implementation, and evaluation, produced a report and integrated different communication channels to keep the conversations and reflections open after the conference.

3. Building a TIP KI through outcomes of the experimental conference

This section maps the results of the executed MEL plan for the conference. We first discuss how the conference contributed to learning and unlearning among participants (O2) and aligning diverse perspectives on TIP (O3). We then analyse how the conference fostered broadening and deepening networks of actors pursuing transformative initiatives and their learning processes (O1). We then reflect on the materiality of the infrastructure and how it contributed to the intended outcomes. We address how non-traditional conference approaches can aid in transcending blockages that hinder transformation pathways (O4) in Section 4.

3.1. Different knowledge, visions, and learning on TIP

The pre-conference questionnaire and the analysis of the initiative forms sent to the conference provided a view of the expectations of participants and their motivation to participate, summarised in Fig. 2.

The conference delegates were motivated by the prospect of gaining knowledge about different aspects of TIP theory and practice. Some expectations were oriented to key conceptual areas of the TIP research agenda (Ghosh and Torrens, 2020), and others were more nuanced around the learning and experimentation processes.

Regarding the diversity of knowledge, according to the post-conference survey results, a majority (65 %) of presenters at the Conference perceived that a good mix of academic and non-academic knowledge was shared. One interviewee (I6) in the in-depth interviews remarked that they especially liked that not only academic knowledge was shared through the presentations but that there was a "multi-level conversation".

Despite the majority of academic participants, the conference was designed to foster the integration of different kinds of knowledge, not only codified academic knowledge but also knowledge acquired through practical experiences. The observers reflected that academic initiatives inviting policymakers as panellists exemplified the openness to other kinds of knowledge, willingness to go beyond theories, and willingness to make their policy research more relevant. Assessing the quality of the transdisciplinary discussion spaces that the conference provided, the observers reported that the conference organisers, facilitators and session speakers demonstrated a reflective approach to learning and unlearning by showing openness and acceptance of positive and negative feedback. This is further validated through surveys. 68 % of the speakers who responded to the survey shared positive feedback on the extent to which new ideas and alternative definitions to problems and solutions were shared.

However, evidence showed that less structured spaces where participants with similar interests gathered were more dynamic, and participants felt more inclined to share their perspectives openly. The observers noted that "…in 'small groups, rich discussions where nobody had 'control' over the conversation (for example, speakers or experts), participants felt safe sharing critical thoughts and personal experiences… Here, the conversations grew deeper." This quote shows that the idea of space is more nuanced than the digital platform itself, relating it to people and attitudes - one where the participants feel safe to voice their knowings, unknowings, and understandings, which is critical to build a knowledge infrastructure. All the sessions had moderators who played a vital role in creating this safe space. The degree of moderation differed across sessions. In some sessions, moderators restricted themselves to timekeeping, whereas in others, they intervened with a remark or question that triggered further comments and reflections. They also encouraged the audience to speak or engage in chat functions, which often empowered participants to say something, which is an important enabler for diverse knowledge inputs.

Concerning visions of transformation, looking into the submitted initiatives, we identified four main clusters that showcase diverse meanings about what transformation implies:

1. A systemic approach to social problems that can be solved partially through science and technology, highlighting the importance of connecting industrial practices, learning and capabilities needed to approach complexity.
2. Context-based experimentation that matters both in space and scale. There was an emphasis on looking at micro-processes as essential to understanding and triggering transformative pathways and fostering cross-sectoral learning.
3. The relevance of governance to empower communities, citizens, and grassroots organisations by creating inclusive, participative, collaborative spaces leading to reflection and transformation.
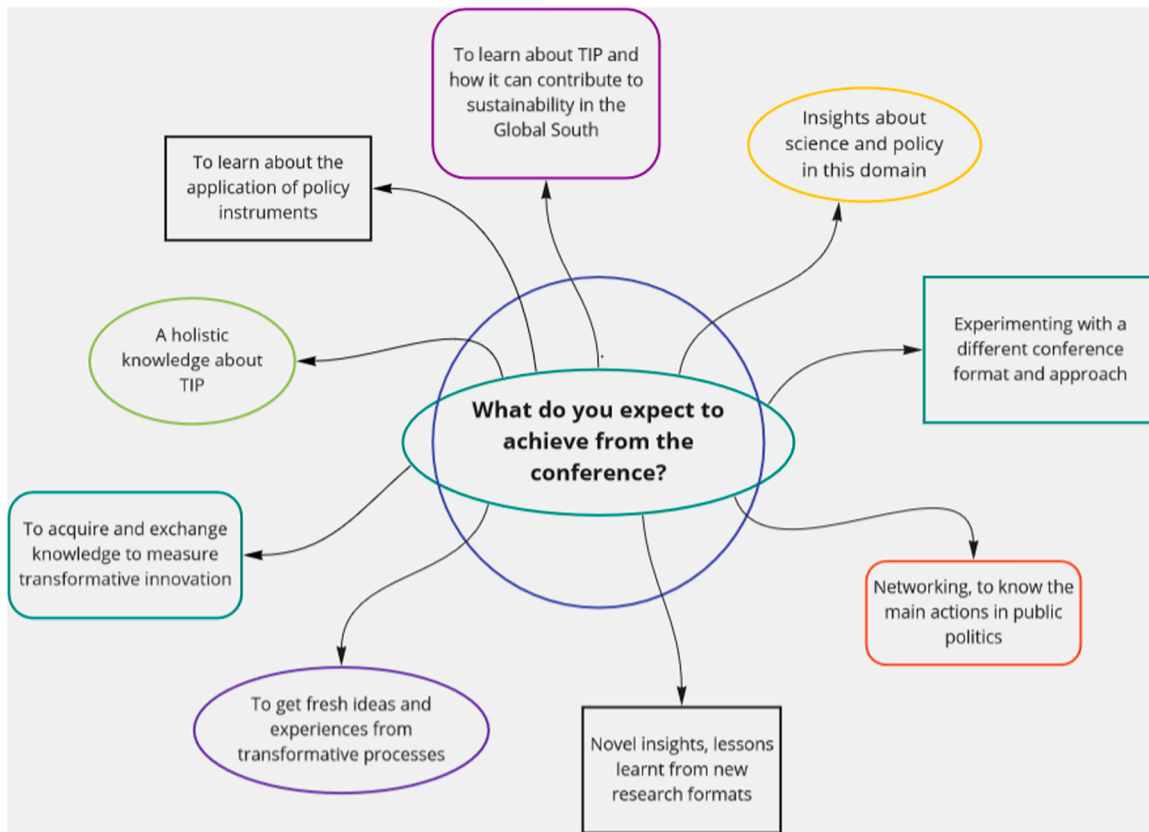
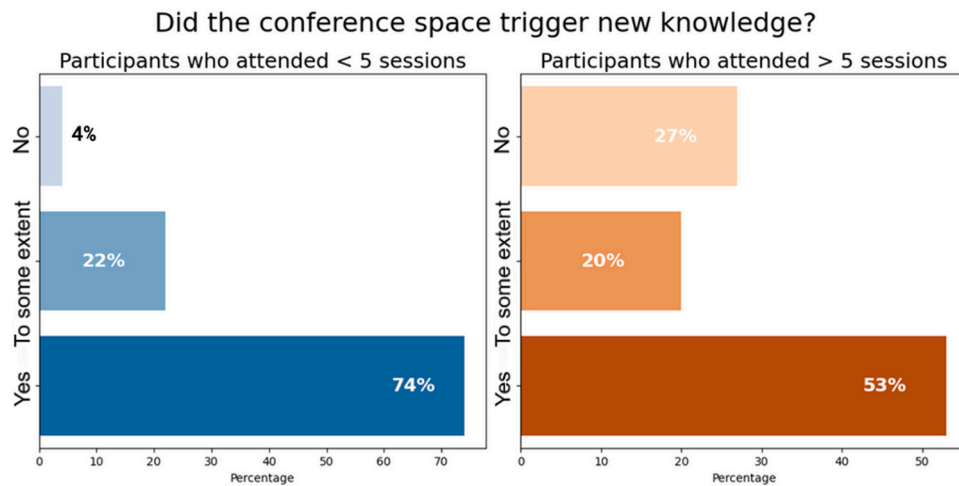**Fig. 2.** Participants' expectations for the conference.

Fig. 3. New knowledge.

4. Need to build a robust knowledge infrastructure that includes different types of knowledge and allows learning among different actors and sectors.

We note that each of these clusters contains multiple themes, interconnections, and significant overlaps, e.g. the focus on inclusivity and learning is present in multiple articulations of visions. This highlights what transformations mean: even arising from diverse sources, meanings can converge towards the complexity of fostering transformation, which requires a systemic approach to experimentation that distinguishes different contexts and governance approaches. The knowledge infrastructure cluster highlights the need for convergence mechanisms

and platforms for sense-making, sharing, networking, and learning.

When asked about the diversity of visions on transformation, most of the session conveners expressed that they did not encounter any contradictory views or perspectives in their sessions. They attributed this to the programme's design, emphasising the alignment of views over contradictions. However, some participants felt discouraged from debating contradictory ideas due to the limited communication channels, which were mostly restricted to chat messages. Furthermore, the short duration of the sessions may have been another reason why there was little opportunity to explore contradictory visions. Overall, there was a sense of homogeneity in the knowledge shared during the sessions. One respondent to the post-conference survey wrote how the conference

could have been more inviting towards diverse knowledges:

"To invite more critical comments, the sessions could have focused more on questioning assumptions underlying [the research], the limits to the knowledge presented and why there is a need for other disciplines, [and] stakeholders to come in and contribute."

However, attitudes of being open to 'other' kinds and sources of knowledge, including those from outside academia and professional fields, were observed in sessions where the topic was not focused on theoretical concepts but action-oriented problems. For instance, speakers shared case studies of policy practices and compared them across contexts to derive policy-relevant learnings. There was also a session that displayed participatory videos made by local communities in Colombia. In this session, one of the social leaders presented their experience and view on the role of innovation in transforming their community.

While there was no heated debate among participants with conflicting perspectives, their attitudes and openness to diverse perspectives shed light on the potential for developing a knowledge infrastructure (KI) for TIP. According to the speakers' survey, most (65 %) believed that a balanced blend of academic and non-academic knowledge was shared during the event. In an in-depth interview, one participant (I4) noted that there were many practical insights in the sessions and that it made them reflect on integrating different theoretical frameworks into their own research. These findings demonstrate that participants from different backgrounds contributed diverse experiences, resulting in a mix of knowledge communities at the conference.

Similarly, to the question, "*Did the conference space (think of the design of the sessions, the composition of participants in the sessions, etc.) trigger new problem definitions, new conceptualisations, alternative narratives and methodologies?*" participants reported that a diversity of ideas, frameworks and methodologies were shared during their sessions. The graph below exemplifies this:

Overall, the organisers deliberately designed processes to include contents, spaces and methodologies to foster second-order learning in terms of knowledge, attitudes and interactions following principles of reflexive monitoring in action (Van Mierlo et al., 2010) and social learning (Beers et al., 2016).

3.2. Networks and learning

In Fig. 2, we can see a network analysis of the initiatives presented at the conference by the authors.

Fig. 4 shows the network of people collaborating in different clusters. The node size represents the number of connections of the person, and the arches represent the connection with other people through their co-authorship in the initiative proposals. The network shows prominent clusters from people based in European countries and within European countries, with very interconnected nodes from Nordic countries. TIPC researchers collaborate amongst themselves but also connect with authors from different regions. The map provides a view of the social constellation of the conference from the teams presenting initiatives. It is worth highlighting that some of the bigger nodes in the map are non-academic actors working in policy or intermediary organisations. Moreover, 93 % of the participants who participated in more than 5 sessions reported that they expanded their network.

The conference offered informal spaces for building trustworthy networks, which created conditions for holding fluid conversations and showing honest, direct, and mutually challenging knowledge exchange among delegates, according to the observers' report. Looking at these results, we can see how the sessions stimulated interactions, even between participants who were meeting for the first time. Given the characteristics of the call for initiatives and the diverse origins and backgrounds of participants, the conference gathered different participants who shared ideas and engaged in discussions both at the sessions and through the platform tools.

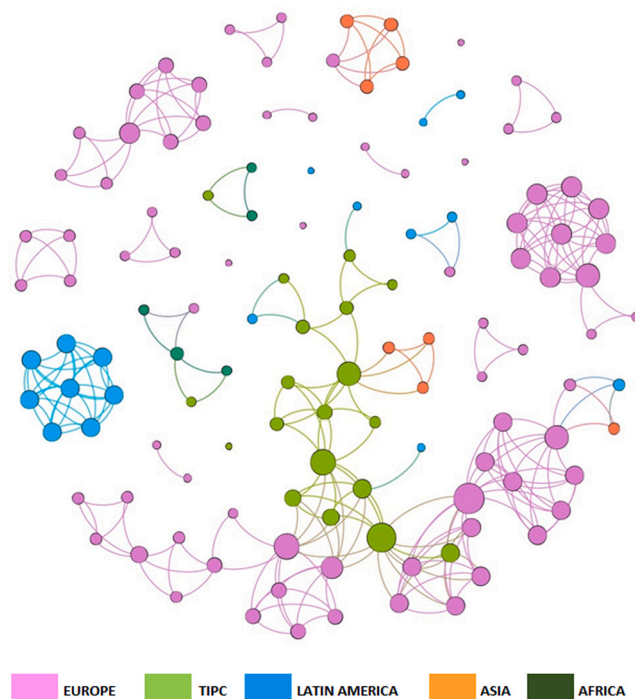The strength of the network building was also associated with the

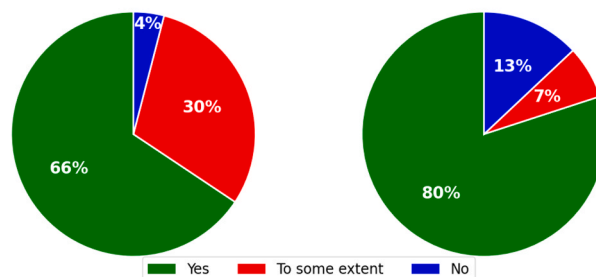**Fig. 4.** Network of authors of submitted initiatives.

Fig. 5. Mutual reflection.

depth of the discussion achieved when panellists knew each other from before. Panellists built their arguments at a higher level, implicitly based on the assumption that the basics are known and long debated, challenging each other as continuing from and building upon previous conversations. Such panel sessions which were otherwise deemed as not so inclusive were also the space where listeners experienced more depth in the topics discussed. Such implicit understanding indicates the initiation of building trust and it is a stepping stone towards strengthening networks.

While the speakers expressed during the conference survey that they were sceptical about the best possible outcome of the sessions in terms of broader engagement, the opportunities for following up conversations in the networking sessions, and the chat and video chat functions of the platform presented further options to expand networks. The data gathered through the digital platform where the conference was hosted, shows how individuals reached out to each other through direct chat messages and video calls. The option of 'Let's chat on Slack' had 88 clicks, and for the networking tables, 112 messages were sent, gathering 303 participants in the digital rooms. In general, at least 127 messages were exchanged, and 615 connections were made through the conference platform. This data shows how the social constellation evolved and changed, revealing interactions between people, some of whom were

previously disconnected from one another. However, to broaden and deepen these networks a durable infrastructure is necessary, which goes beyond a temporal space, such as a conference. This is one of the aspects highlighted and considered before and after the conference.

73.3 % of speakers reported in survey responses that their sessions had less than 30 participants and that the level of interest and enthusiasm among the participants to contribute to the discussion was very good (9 %), overall good (45 %), OK (30 %), and could be significantly improved (16 %). The surveys, interviews, and observers' reports showed positive feedback on listening to each other's points of view in a respectful environment. Participants felt they were being listened to when they shared their experiences based on ongoing practices.

The number of sessions attended by the participants also had an impact on learning. The post-conference survey showed that among the participants who attended more than 5 sessions, the majority found the conference space to be conducive to triggering new problem definitions, new conceptualisations, alternative narratives, and methodologies.

To the question, *Did you feel: "what I know needs serious questioning" at any point during the conference so far?"*, which intended to capture second-order learning, two-thirds of the comments on open-text answers indicate that the respondents acquired new knowledge/visions, new insights and understanding by hearing perspectives from experts and practitioners. There was also a positive comment about the increase in taking up TIP thinking and the decline of a conventional "modest witness" perspective (regarding visions).

To the question, *Did the TIP conference 2022 provide a space for mutual reflection?* an outstanding majority responded yes to this question. This was later supported by an interviewee (I5) who reflected that it was helpful to see that other people in similar research and practice fields struggle with the same questions and issues.

A critical part of building a KI is not only to build a network but also to sustain it. The conference participants offered several suggestions: to keep the communication and the platform alive, either continuing to have monthly or bi-weekly virtual sessions or organising discussions around shared challenges. It was also said that having an event once a year which brings back the people in this working/research area and where they can talk about their progress and milestones and share their experiences would be conducive to maintaining communication and collaboration. A Slack channel[6] to keep the conversation ongoing was created during the conference, and it is still open to the participants. During and after the conference, when delegates were asked whether they wanted to keep the discussions ongoing after the conference, for instance, through Slack, a clear majority of 71 % of respondents responded "yes". In contrast, only 15 % answered "to some extent", and 14 % answered "no". Also, as a result of the conference and to build a durable knowledge infrastructure and nurture the new and previous networks, the organisers created the TIP Knowledge Community hosted in the TIP Resource Lab,[7] where people, places and practices are connected, providing open access for consultation and inclusion of transformative initiatives.

3.3. The digital space as a tangible knowledge infrastructure

The conference was a significant milestone in providing resources for building a knowledge infrastructure. The digital space was essential for networking, learning, and unlearning, but it was only one of the means that enabled the experience. The design, planning, and logistics were the base of bringing this infrastructure to life. From its inception, the conference was deliberately designed as an enabling space for sharing experiences. The learning sessions were particularly noteworthy in this

regard, taking place every day and welcoming all delegates to reflect on and share their thoughts on their experiences related to the conference's activities. These sessions were structured around each of the conference's outcomes, providing a focused and engaging way to discuss and learn from one another.

Moreover, the programme structure, including the format of the sessions, was carefully planned. Long presentations are not congruent with transdisciplinary conversations as they can restrict active dialogues and be dominated by one individual or a particular perspective. A detailed guideline for the speakers on how to maximise inclusive reflection in their sessions was crucial to foster interaction. The programme overall intended to create rich interactions fostering attitudes of trust, openness, and urgency to act.

There was also a diversity of channels and ways the digital space was used during the TIP Conference 2022. Within the conference platform, several features were mobilised to enable conference participants ample opportunities for networking, learning and knowledge exchanges. One interviewee (I7) remarked that this was a conference, "strongly supported by the virtual experience of different formats smartly used to create a maximum of interaction between different attendees". They added that "learning happened through creative engagement with the use of various applications such as MIRO, Mural board, Slack and other methods of knowledge exchange in various sessions. Creativity (such as the use of Mural and MIRO, and Slack), empathy, and acceptance of different viewpoints ensured that the needs of conference participants were met." The table below shows the features of the digital platform used to create further engagement.

All interviewees agreed that the digital space of the conference provided some opportunity to talk without barriers and to express their personal opinions freely. They describe a very good experience and praised the open interactive format: *"It was made very easy and possible to share ideas, to get answers on ideas – even in the live stream format via chat and in the Zoom sessions directly and in the breakout sessions even on a 1:1 basis." (I7)*

Although most delegates had very good experiences with sharing their opinion and being equally respected, the observers' report highlights that there are still power dynamics at play and dominance exercised through the technological platform either by those who are more experienced and proficient in using digital platforms or by those regarded as experts in a certain topic. This was particularly observed in engagements through the chat function, where experts' input was accepted or, at least, less disputed than other inputs from people with less influence. The provision of digital infrastructure does not, therefore, guarantee equal and fair participation. However, this can be potentially mitigated through the active role of the session moderators.

Regarding temporality, providing alternative channels for keeping the discussions open is a way to attempt to strengthen the KI. However, as one interviewee interestingly remarked (I3), keeping the interest to expand new knowledge given the scarcity of resources, mostly time, is challenging even if the platforms are provided.

4. Our framework: a knowledge Infrastructure that fosters transformation pathways

Building a sustainable and inclusive KI to foster systemic transformation pathways was the long-term goal of the conference. We showed how the conference's ToC set four outcomes that could contribute to that purpose (Fig. 1). In the previous section, we analysed three of the four outcomes: the ones related to networking, learning and integration of diverse perspectives on transformation. The fourth outcome (O4) stated that non-traditional conference approaches can be a mechanism to transcend blockages that hinder transformation pathways. With that purpose, a ToC and a MEL plan were developed by the organisers following an experimental approach. The extent to which O4 was advanced can be only partially seen, as was reported in Section 3. However, we can distil from the case study that broadening and

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deepening networking is crucial to building communities of practice, that aligning diverse visions towards transformation pathways contributes to knowledge integration and that learning and unlearning are central for resilient and action-oriented communities that address sustainability challenges. As remarked by Cornell et al. (2013), learning takes place through the co-production of knowledge from the engagement of multiple and diverse actors, enabling joint problem framing, knowledge integration and experimentation. Research collaborations that include scientists from different disciplines, as well as non-academic stakeholders from business, government, intermediary organisations, and civil society, are crucial to overcoming transformational failures (Lang et al., 2012: 26; Ghosh et al., 2021) and conferences are a good platform to foster these collaborations.

Critical arguments for this new type of research collaboration on complex sustainability problems that transcend disciplinary and interdisciplinary approaches are: 1) Complex challenges require constructive input from various communities to ensure that essential knowledge from all relevant disciplines and actor groups is incorporated; 2) Addressing complex systemic problems necessitates knowledge generation that extends beyond mere problem analysis placing an emphasis on formulating strategies and visionary approaches that serve as guiding principles for effective interventions; 3) collaborative efforts between researchers and non-academic stakeholders increase legitimacy, ownership, and accountability for the problem, as well as for the solution options (Lang et al., 2012:26). Creating spaces where communities of practice, formed by people who engage in the process of collective learning in a shared domain of human endeavour (Wenger, 1998, 2002), is critical to foster transdisciplinary collaboration supported by a knowledge infrastructure, in this case, for TIP.

In this section, we introduce our framework for constructing a KI for TIP. Drawing upon the insights gleaned from our comprehensive case study, we recognise the importance of materiality, manifesting through both tangible and intangible infrastructures, in facilitating the formation of communities of practice that continuously advance knowledge integration. To establish vibrant communities of practice, the orchestration of collaborative activities and the sustained mobilisation of agency over an extended period emerge as pivotal components.

When it comes to knowledge integration, it is imperative to empower members within the community of practice to articulate their expectations and engage in experimentation with diverse solutions aimed at aligning concrete evidence. This process is instrumental in promoting both first and second-order learning and unlearning, creating fertile ground for challenging assumptions and reevaluating problems and solutions. In Fig. 6, we visually depict the intricate interplay of these essential elements that serve as guiding principles for our analysis.

4.1. Towards knowledge integration

A starting point for building a KI is to acknowledge that there are many types of knowledges: codified and tacit, from different communities, and with different types of access. Knowledge is also held at an individual level and transformed across groups. Hence, a KI requires the integration of such a diversity of knowledges. Diversity refers to the breadth of knowledge categories in an interdisciplinary research field (Liu et al., 2012). Diversity can also be mapped through knowledge from academic and non-academic backgrounds and knowledge practises in different cultural contexts (Preuß et al., 2021).

Knowledge integration requires the articulation and convergence of different bodies of knowledge, emphasising the formation of a 'meaningful constellation' (Liu et al., 2012). In transition research, knowledge coherence is best seen when the expectations of multiple actors are aligned. In an organisational context, knowledge integration is defined as "the capability to *assimilate* the insights from the dialogue with stakeholders and to *transform* this knowledge into the organisational processes" to adapt to changing environments and uncertainties (Veldhuizen et al., 2013: emphasis added). This definition emphasises assimilating and transforming theory-driven and problem-oriented knowledge for solving 'real world problems' (Zierhofer and Burger, 2007), which is directly related to transdisciplinary practices. It also connects with the idea of 'Integration and implementation sciences', where different disciplinary 'stakeholders' collaborate and apply this newly combined knowledge to solving societal and sustainability challenges (Bammer, 2005). Hence, a KI does not only include constellations of diverse knowledges, but also knowledge conversions, which
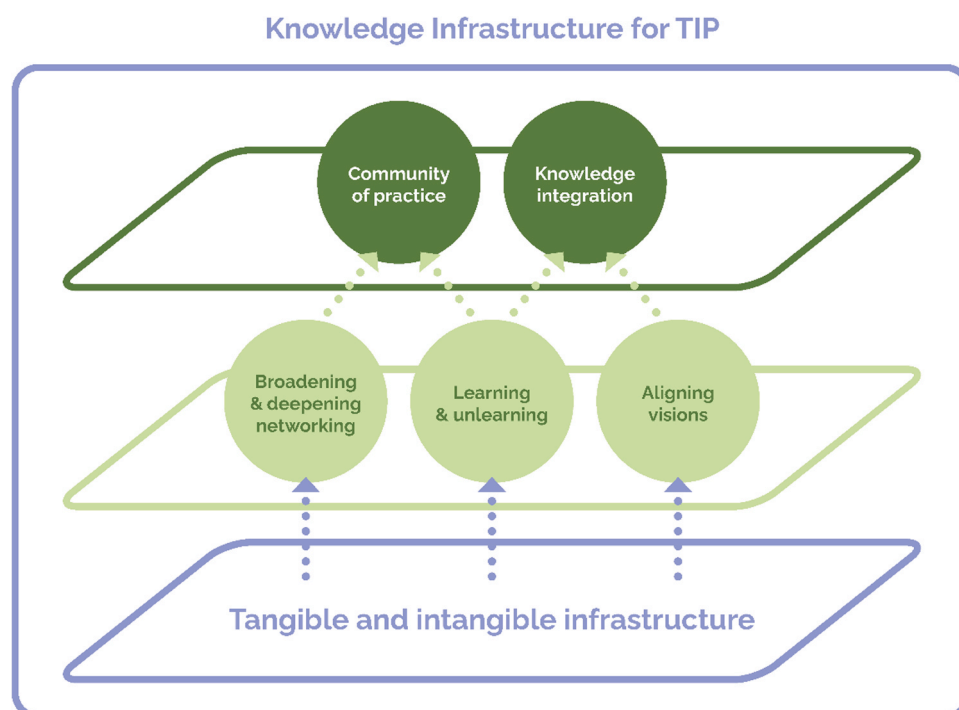

Fig. 6. A Knowledge Infrastructure for TIP.

contravenes the mono-disciplinary and specialised practices of knowledge production among academic elites (Nonaka et al., 1996).

We observe that temporary settings, such as conferences, have the potential to facilitate the fusion of academic and non-academic knowledge, providing resources for knowledge exchange, wherein collaborative problem-framing and developing shared visions become indispensable elements.

As illustrated in the previous section, this format has proven effective in encouraging participants to reconsider the boundaries, scope, and transformative potential of transdisciplinary knowledge infrastructures, ultimately paving the way for profound changes and innovative solutions.

4.2. Towards a community of practice

According to (Wenger, 1998, 2002), communities of practice share three elements: 1) **A shared domain of interest**: Membership implies a commitment to the domain and, therefore, a shared competence that distinguishes members from non-members; 2) **The community**: In pursuing their interest in their domain, members engage in joint activities and discussions, help each other by navigating challenges, and share information from their areas of practice that might be helpful to others. They build relationships that enable them to learn from each other; they care about their standing with each other. 3) **The practice**: Members of a community of practice put their knowledge into practice and produce new knowledge from their practice in a virtuous cycle. They develop a shared repertoire of knowledge and resources: experiences, stories, tools, and ways of addressing recurring problems—in short, a shared practice. This takes time and sustained interaction. The combination of these three elements constitutes a community of practice. Furthermore, developing these three elements in parallel cultivates such a community.

Therefore, a KI designed to support the TIP community of practice places social learning at its core, promoting ongoing processes wherein knowledge translates into actionable outcomes. This transformation extends to individual and collective realms. By fostering networking and aligning collective visions, the community enhances its capacity for impactful action. Furthermore, it unlocks its potential to drive transformation within unsustainable socio-technical systems, directly influencing their contexts. As illustrated in our case study, when individuals who share common interests and are connected through similar networks convene, robust and enriching debates ensue. Participants gradually become more comfortable voicing their disagreements, offering compliments, or providing critiques, thus fostering a culture of knowledge integration.

Lastly, communities of practice must have spaces that facilitate encounters among diverse groups, encompassing differences in location, nationality, gender, experience, seniority, and background. The monitoring of these communities' expansion can be accomplished through various methods, such as network analysis, surveys, or interviews. Our case study exemplified the practical application of these methods within a specific context, namely, a conference setting.

4.3. Tangible and intangible support to KI

We argue that knowledge integration and transformative communities of practice are core elements for building a sustainable and inclusive KI for systemic transformation pathways. Such a KI for TIP requires digital or physical (tangible) spaces and deliberate designs (intangible spaces) to foster its realisation, such as the TIP conference 2022.

In day-to-day use of the word, knowledge infrastructures are books, libraries, classrooms, or science labs. These are tangible or hard infrastructures. For knowledge integration, digital platforms are often the hard infrastructure that facilitates the assimilation of diverse knowledge into integration, transfer, and translation. The tangible materiality of a knowledge infrastructure includes platforms where communities share informational, educational, organisational, and cultural resources (O'Dubhchair et al., 2001). Those platforms should allow a broader base of knowledge producers to challenge, rethink and rewrite the past, present and imagined futures of a rapidly changing social world in an open and interconnected way (Edwards et al., 2013). The materiality and durability of knowledge infrastructures are underlined by ways of gathering, creating, integrating, and transforming knowledge constellations. Enabling open spaces, be they physical or digital, to strengthen actionable alternatives proposed by communities of people who experiment and learn together is critical to the durability of the KI.

The intangible elements of a KI constitute robust networks of people and institutions (Edwards et al., 2013) that develop capacities, communication styles, social norms, and ethical considerations around power structures that influence the qualification and value of knowledge (Anderies et al., 2019). For example, we discussed how the conference enabled, to an extent, the formation and strengthening of knowledge constellations. However, the restrictions of the platform (letting participants intervene by video and voice in plenary sessions) and the predominance of academic knowledge hindered further knowledge exchange and contributed to power unbalance. This finding reminds us that neither the tangible nor the intangible aspects of knowledge infrastructures are neutral, as they are constantly negotiated and shaped by knowledge communities (Kranzberg, 1986, O'Dubhchair et al., 2001).

The conference intended to build upon the previous dialogues, conferences, and knowledge domains on TIP and further conceptualise and set bases to create a KI that generates, maintains, and integrates knowledge to achieve social, cultural, economic and environmental outcomes (Huddleston et al., 2022) towards the transformation of unsustainable socio-technical systems. In that regard, the conference was successful as a milestone in providing intangible and tangible resources to hold a TIP community of practice. However, the success of this endeavour can only be seen in the further development of the TIP community and the sustained and collective effort to maintain and keep shaping the KI.

5. Conclusions

We propose that a KI for TIP is built on the foundations of an inclusive knowledge system that includes transformative communities of practice and new ways of knowledge integration. The TIP Conference 2022 provided elements to reflect further on the concept and practice of building a KI for TIP. Despite all the efforts around the TIP conference 2022, a KI for a broad and complex research area such as TIP cannot be built with one milestone, such as a conference. While the journey has started and has gained momentum, the next step of such a journey is maintaining, nurturing, and institutionalising the infrastructure. Institutionalising, in the literature on sustainability transitions, implies stabilising and standardising practices, making them mainstream and permanent and making durability a critical aspect. Hence, institutionalising a KI for TIP means putting further efforts into sustaining the infrastructure. Durability is ensured by keeping the infrastructure dynamic - ensuring that the infrastructure co-evolves with the knowledge while simultaneously being mobilised for furthering knowledge integration and application in the real world. Currently, multiple efforts and endeavours are emerging from the TIP community to institutionalise this knowledge infrastructure: e.g. creating the TIP Resource Lab that shares tools, actions and learnings from the past years of the TIP Consortium's policy experimentation and evaluation work; building a 'network of coaches' who are mobilising the tools and learnings from the Resource Lab; a TIP Knowledge community, which embodies the very definition of the 'TIP community of practice' – a complex database of people and projects, across places. These initiatives enable future collaborations, joint research funding, and advancement of the heterogeneous knowledges of TIP beyond the lifetime of the TIP Consortium.

Since the conference was designed to be a milestone towards building a TIP KI, the monitoring and evaluation process tracked changes in knowledge, attitudes, and interactions as important blocks for learning and unlearning before, during, and after the TIP conference. The conference was positioned as an "Agora of social learning" (Schauppenlehner-Kloyber and Penker, 2015), providing a dynamic and participatory space where individuals and groups came together to exchange knowledge, experiences, and ideas related to a specific topic or issue. In that sense, the conference extended and reinforced other platforms, such as the TIP Consortium and the academic networks involved, to foster collaborative learning, enabling diverse stakeholders to interact, share insights, and co-create solutions. The conference served as an "agora" by providing a gathering space, emphasising the open and inclusive nature of the learning environment.

Our data analysis has unveiled several critical factors that either facilitate or hinder the construction of such a Knowledge Infrastructure. Among the pivotal enabling factors is the rich tapestry of knowledge diversity, encompassing academic and practical expertise. The dynamic interplay of diverse perspectives and expectations must be thoughtfully addressed and harnessed during the knowledge integration process. When looking at hindering aspects, we highlight the need to acknowledge and actively address existing power dynamics among participants within the KI. Despite creating open and collaborative spaces, academic hierarchies often intersect with the perceived value attributed to the voices of different knowledge contributors. As such, developing mechanisms aimed at inviting and safeguarding the inclusion of a multitude of voices should be an integral part of KI construction.

The theory of change developed before the conference does not perfectly align with the components of the knowledge infrastructure (KI) discussed in this paper. To clarify, our understanding of "what a KI is" was constructed retrospectively, drawing from the conference analysis where establishing a KI for TIP was a central theme. For example, developing a community of practice, a key element of the KI for TIP, emerged from observations during the conference. This retrospective approach enriched and strengthened the conference findings, making them more robust and applicable across contexts.

This paper also serves as a reminder of the untapped potential of academic conferences. We have problematised the purpose of an academic conference, experimented with it, and stretched the diverse possibilities for transdisciplinary action-oriented research conferences to be impactful. Techniques and lessons from organising and participating in the TIP Conference 2022 may be valuable for those in other academic fields to connect research and higher education with impact.

CRediT authorship contribution statement

Laura Winkler: Data curation, Formal analysis, Investigation, Visualization, Writing – review & editing. **Diana Carolina Velasco:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. **Bipashyee Ghosh:** Conceptualization, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft. **Alejandra Boni:** Conceptualization, Formal analysis, Investigation, Writing – original draft. **Katharina Schiller:** Conceptualization, Methodology, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Availability

Data will be made available on request.

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Annex A

Interviewees I Background

Interviewee 1 (**I1**)	Female/Senior advisor/Ministry of Foreign Affairs working on issues on development/ connections to Africalics network and Globelics
Interviewee 2 (**I2**)	Male/Innovation and public policy researcher based in a renowned Indian high education institute
Interviewee 3 (**I3**)	Female/Senior academic/Malaysia
Interviewee 4 (**I4**)	Male/Junior/Colombia-Brasil junior academic
Interviewee 5 (**I5**)	Female/Senior/Mexico Consultant/former policy maker
Interviewee 6 (**I6**)	Male/Senior/Central American/independent researcher related to Globelics
Interviewee 7 (**I7**)	Female/Senior/Austrian Policy Maker
Interviewee 8 (**I8**)	Male/Junior academic/Thailand

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