



Article

Like Stones in The River: Understanding The Nature of Boundary Objects in Participatory Futures Workshops

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Abstract

The ability to imagine futures collectively is important in coping with evolving and uncertain environments. However, how knowledge is exchanged and produced in such participatory approaches toward futures thinking is not thoroughly understood. Therefore, this in-depth case study of futures workshops assesses the nature of knowledge and the role of boundary objects. The results shed light on how different media, which embed multiple types of knowledge, stimulate participants' imaginations. A carefully chosen sequence of knowledge-generating activities provokes this effect. These insights add to the practical and academic knowledge in the field of futures studies.

Keywords

Participatory futures workshop, Foresight knowledge, Boundary objects, Imagination, Futures thinking

Introduction

Modern society is facing several complex challenges that require a cross-sector approach involving different levels of society (Bezerra & Brasell-Jones, 2005; Peters & Tarpey, 2019). To ensure the success of such approaches, an open, critical, and anticipatory attitude toward future obstacles and opportunities is required. However, the information required to tackle such problems is often unclear and distributed among different actors (Lakhani & Panetta, 2007). Although collaborative efforts from a diverse set of actors facilitate interactions between them and promote (reciprocal) knowledge exchange (Carayannis & Campbell, 2012), the distributed knowledge may lead to bias, confusion, and uncertainty (Lakhani & Panetta, 2007). Furthermore, each actor has their own expectations for the long-term future (Grunwald, 2014). The capacity to incorporate the expectations of others stems partly from our imagination (Moore & Milkoreit, 2020).

Specific methodologies are being developed to enhance our imagination and enable us to cope with the ambiguity of future-oriented knowledge. The causal layered analysis methodology (Inayatullah, 1998) is an example because it stimulates both creative and critical thinking (Balcom & Heinonen, 2019). Another approach is a participatory futures workshop, which involves participatory methods for the creation of knowledge on different aspects of the futures (Heino, 2021). This approach allows us to focus on the rich human imagination by envisioning what is not (yet) perceivable with our senses (Roßmann, 2021), and it also considers the value of including multiple perspectives (Brugnach & Ingram, 2012). Articulating boundary objects is a useful way to support this approach. Boundary objects are artifacts that embody their creators' implicit and explicit knowledge (Boland & Tensaki, 1995). However, how distributed knowledge transforms into boundary objects and how they relate to the development of new knowledge is not clearly understood (Star, 1989). Hence, to better understand the dynamics of knowledge transformation in the co-development of futures, this study examines how some boundary objects, such as drawings,

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personas, or cardboard designs, act as imagination enablers, allowing the reflection of future challenges.

To unravel these processes, an in-depth case study was conducted in the context of a participatory futures workshop. The analysis is based on a framework that will be discussed in the background section of this paper and includes five key dimensions: (1) the nature of knowledge exchanged among project participants, (2) the relationship between the knowledge and the artifacts constituting boundary objects, (3) the collaboration paradigm determining how intense the co-working process is, (4) the restrictions, meaning the characteristics and opportunities of the different workshop phases, and (5) the imagination strategy, which determines the imagination stimuli applied.

Background

The nature of knowledge

Participatory futures workshops are often considered collective knowledge creation processes (Heino, 2021). In these workshops, new insights are developed as a reaction to other participants' input or in cooperation with them. Sometimes, the workshop's facilitation leads to the creation of new knowledge, but this knowledge generation process is also equally spontaneously.

This section discusses how knowledge can be conceptualized and studied in the context of participatory futures workshops. This paper defines futures knowledge as knowledge generated in the present used to explore futures. This paper distinguishes between five types of knowledge (three explicit and two implicit) featuring currently known information that may evolve in the future (Delanda, 2019). One type of generic and person-independent, explicitly shared knowledge is codified knowledge (e.g., data such as a neighborhood crime rate) (Dufva & Ahlqvist, 2015). A second type of knowledge is articulated knowledge, which is the result of the translation of codified data into a specific context (Dufva & Ahlqvist, 2015). For example, such knowledge includes information on the effectiveness of crime rate reduction programs. The last kind of explicit knowledge is encapsulated knowledge. This type of information is not directly observable; instead, it is embedded in an artifact's design and functionality. For this reason, we call encapsulated knowledge "semi-explicit" (van den Berg, 2013). For example, we do not need to know how a smartphone operates while using the device or imagining future applications (Pfaffmann, 2000).

In addition to these three explicit types of knowledge, embodied or tacit knowledge, a type of implicit knowledge, represents each participant's unique set of (non-expressed) experiences, opinions, and expertise. Such know-how is assumed in actions and conversations (Polanyi, 1966; Simon, 1999). To capture such knowledge from participatory processes, ethnographic research methods, such as observations, are highly suitable (Dufva & Ahlqvist, 2015; Mortensen et al., 2021).

A fifth kind of knowledge, and perhaps the most potent for imagining alternative futures, is out-of-radar or self-transcending knowledge. This kind of understanding is used to reframe what we already know to challenge the evidence and create new ideas or insights (Dufva & Ahlqvist, 2015; Miller, 2018). It focuses on the "not-yet-enacted reality" and can be considered "reflection-in-action", such as associating or broadening (Scharmer, 2001, p.142). It is difficult to express, transfer, or observe out-of-radar knowledge because it is "not directly accessible in the initial context" (Dufva & Ahlqvist, 2015, p. 254).

Out-of-radar knowledge refers to novel information. At first, it might be considered trivial or out of scope, but considering the importance of foresight, it is necessary to move one step further from the obvious. However, this requires effort from participants, as some must leave their comfort zones to make free associations. Dufva and Ahlqvist (2015), Miller (2018), and Scharmer (2001) refer to this type of knowledge as unknowable unknowns. There is often no root of these unusual elements in the past or present; thus, we cannot link them to any repetition or continuation of events.

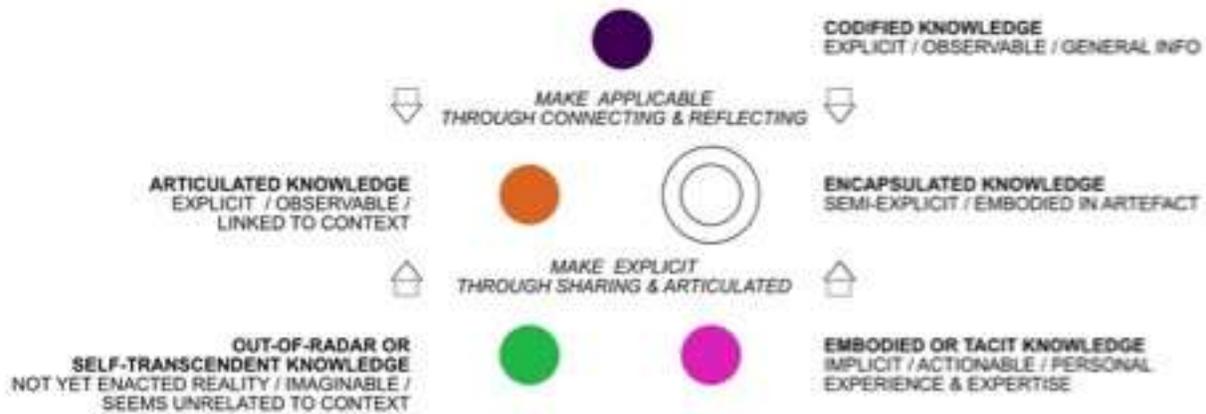


Fig. 1: Different knowledge types can be structured according to the following scheme. (Adapted from Dufva & Almqvist, 2015; Scharmer, 2001; van den Berg, 2013)

Several methods have been developed to transfer participants' implicit desires and inspirational views about the future—that is, tacit and out-of-radar knowledge—into articulated, and thus shareable, information. In the participatory futures workshop context, these methods often include group discussions, storytelling, or role-playing (Dufva & Almqvist, 2015; Miller, 2018). While the potential of these types of knowledge has been recognized, it is less clear how they are used afterwards in the workshop.

Therefore, this study analyzes the nature of knowledge exchange and development in participatory futures workshops based on the types of knowledge illustrated above and derived from Dufva and Ahlqvist (2015), Scharmer (2001), and van den Berg (2013). Furthermore, an important aspect of interest in the field of participatory futures is the development of artifacts, which will also be discussed.

Boundary objects in participatory futures workshops

Hedlund (1994) stated that “a tangible product is knowledge in a highly articulated form” (p. 79). An artifact can only be evolved towards a boundary object through the interplay between different actors as they co-construct its meaning (Thomas, Hardy & Sargent, 2007). Furthermore, boundary objects ease the reading of other meanings by groups with distinct backgrounds or goals (Sapsed & Salter, 2004). Sharing knowledge and thus traversing the borders between these groups can lead to innovation (Kimble et al., 2010). A boundary object, including knowledge made available for reasoning and transmission, facilitates dialogue between one's own represented understanding and the viewpoints of others (Boland & Tenkasi, 1995). Therefore, boundary objects should be considered to have an encoded meaning that can be decoded in multiple ways (Star & Bowker, 1999). This exchange of perspectives is central to what makes a boundary object valuable (Star, 1993).

The added value of a boundary object as a means encouraging reflection, is twofold: it allows one to understand their automatic practices and, to stay receptive to additional knowledge (Rubinstein et al., 1984). Furthermore, boundary objects can induce emotions among those who build the object and its receivers. They not only affect but also generate a stimulus for change (Groot & Abma, 2021).

Prototypes, cognitive maps, idealized images, and other documents can act as boundary objects. Narratives are used less frequently in the field of innovation. However, they are particularly suitable as boundary objects because of their open character; they provide questions rather than answers (Islind et al., 2019). Hence, this paper studies the role of boundary objects in participatory futures workshops.

Collaboration paradigms

Working in a group is beneficial for transforming knowledge from tacit to explicit (Miller, 2018), as only considering the information shared by individual participants would be limiting and would not depict the richness of the participatory workshop context. Undoubtedly, sharing knowledge fuels imagination and makes diffuse knowledge actionable (Backer, 1991).

Furthermore, the exchange of conflicting and divergent ideas is necessary to develop creative solutions. However, a secure and communicative environment is required to give people the courage to speak and share their thoughts, and it is important for them to know that someone is listening to them (Hawkins & Rezazade, 2012).

The practice of co-designing in workshops has been studied from different perspectives, from interactions and outcomes to value creation. Zamenopoulos and Alexiou (2020) outlined two dimensions defining the nature of such collaborations: (1) how common goals and values are aligned among participants, and (2) the intensity of working together. Therefore, this study investigates the relationship between these collaboration dimensions and the nature of the generated and exchanged knowledge.

Restrictions: Phases in participatory futures workshops

Regardless of how people co-design, each participatory futures process consists of different phases and actions. Typically, when studying cognitive processes, two types of alternating thinking are discovered: divergent and convergent thinking (Mumford & Gustafson, 2007). The first relates to nonlinear and spontaneous exploration. The latter refers to filtering, discussing, and selecting the gathered information.

Divergent thinking is important because analytical thinking has not been sufficient to address complex challenges, such as envisioning alternative futures. While divergent thinking techniques support the free expression of a stream of consciousness, they also trigger the unfolding of the capacity for empathy and enrich the perspective on hypothetical and undefined situations (Manzini & Cullars, 1992). Divergent thinking offers multiple tools, such as brainstorming, that allow people to reframe the way in which they understand a problem, develop derivative ideas from a variety of perspectives, and share their inconsistent thoughts (Mumford & Gustafson, 2007).

Equally valuable in the co-design process is the moment when all information comes together (Kunseler et al., 2015). In participatory futures workshops, such convergent phases follow divergent activities. Especially in the context of futures where there are many uncertainties, a pitfall one should avoid is the endless search for new knowledge. Convergent stages could occur at the end of a brainstorming session to add structure to the flood of ideas and prioritize some of them. Depending on the goal of a project, a plenary discussion or a mind map could be a suitable technique for convergence (Vidal, 2006). However, more creative methods, such as performances, songs, or games, could be equally relevant.

In any case, when engaging participants in generating multiple collective futures, ample time should be invested in reflection, both individually and in groups, so shifts in thinking can still occur during the development process (Miller, 2018; Zamenopoulos & Alexiou, 2020).

Imagination strategy

The last analysis dimension focuses on the role of imagination in knowledge generation during participatory futures workshops. In this context, imagination is considered the "[...] making present what is actually absent from the human senses" (Arendt, 1978, p. 75). The challenge of empowering people to engage in foresight activities is twofold: they need to learn both to sense fictional worlds and to make sense of them (Miller, 2018). In other words, imagination-triggering activities focus not only on the materialistic part of fictional images but also on the use of emotions.

Therefore, such activities can be linked to other mental processes, such as learning and meaning-making (Zittoun & Cerchia, 2013). This has also been recognized by Kind and Kung (2016), who highlighted the tension between the transcendent and instructive use of imagination. We either (day)dream or break away from reality (i.e., the transcendent use of imagination) or we make decisions and prognoses about the future and learn (about the current state) (i.e., the instructive use of imagination).

Another relevant distinction is the difference between “imagination with-making” and “imagination without-

making” tasks (Tsai et al., 2023). Imagination without-making, or “visual imagery”, is the kind of activity that triggers the brain but does not require that the body acts. Oral brainstorming is an example. Conversely, imagination with-making activities have to do with visual, tactile, and kinesthetic involvement (Tsai et al., 2023). Every practical activity, such as prototyping or writing exercises, falls into this category. Most participatory workshops consist of a varied set of imagination-triggering activities; we are interested in the knowledge these activities and workshops generate.

Methodology

In the previous sections, we outlined an analytical framework based on five dimensions. Each of these dimensions can be linked to the knowledge flow in participatory futures workshops. In the following sections, we apply this framework to a participatory futures project. Because of the long-term nature of these kinds of projects and the preliminary nature of our research, a multidimensional case study was employed (Yin, 2014). Case study research is suitable for understanding complex issues and can expand knowledge or add insights to what is already known through previous research. Additionally, case study research is most appropriate for processes that are not well understood and/or lacking a (firm) theoretical foundation (Eisenhardt, 1989). Furthermore, open-ended processes are examined at multiple levels (Yin, 2014) so that deeper qualitative insights can be gained.

Yin (2014) defined the case study as an empirical research method that analyzes a contemporary phenomenon within its real-life context, when the boundaries between phenomenon and context are unclear and in which multiple sources of evidence are involved. Given the complicated nature of the observed phenomenon, the multiple levels of analysis required, and the participation of the first author in the studied project, a multidimensional case study design was deemed most suitable.

Case selection and description

The selected case is a project called BrusselAVenir being conducted by an independent not-for-profit organization aiming to depict new narratives for the Belgian capital of Brussels. They build imaginary futures on topics such as climate justice, together with citizens, experts, and creatives.

The BrusselAVenir project was selected based on two criteria: first, the project had to involve the creation of imaginary futures, and second, to have a collaborative nature. The BrusselAVenir project on diversity and living together started in 2020 with a crowdsourcing phase. The project resulted in an audio performance on a tram that took place in March 2023. From September 14–17, 2021, four Futures Labs were organized as part of a summer school’s program in Brussels. As presented in Table 1, each day, an average of six people (total $n = 18$) participated in the structured process designed by BrusselAVenir. On the first day, a brainstorm on the future of mobility, the interior of the tram, and possible interactions took place. On the second day, the participants were asked to reflect (in groups) on their connections with the neighborhood. On the third day, BrusselAVenir shared personas (i.e., archetypal user profiles) (Vallet et al, 2020) and story twisters (i.e., a variety of unexpected situations) (Marshall et al., 2023) as a basis for the testimonials of future inhabitants of the city. On the fourth day, the groups created objects for the future tram. In this process, several media were explored. The outcome from the first two days was drawn by an illustrator who followed the conversations and discussed with the facilitators what he would visualize as input for the next participants. The actors on the third day recorded their stories so that their colleagues in the last session could use them as inspiration for their cardboard objects of the future.

Data gathering and analysis

The following data sources were used in our analysis of the project: (a) transcribed audio recordings from four workshops and a presentation; (b) transcribed audio recordings from meetings with the project owners; (c) survey results (completed after the workshops); and (d) semi-finished deliverables from the project, including post-its, drawings, stories, and prototypes. Beyond these resources, the first author participated as a participant and sparring partner for the facilitating team. Therefore, her own experiences and reflections (participatory observation/action research) are entangled with the research data, adding to the validity and depth of the insights but also

acknowledging and embracing the subjectivity of the interpretation.

This study is based on a combination of inductive and deductive research. After composing both the research questions and the analytical framework from existing theories, we delved into the many transcriptions of the audio recordings. Next, we clustered elements in this rich data until we recognized patterns that led to answers to the formulated question: How do boundary objects transfer knowledge and enable imagination in participatory futures workshops?

Table 1: Agenda of the four Futures Labs

When?	Day 1	Day 2	Day 3	Day 4
Who?	Attending each day: Facilitators E and Kh, Illustrator J (14-2), Researcher E (14-6), and Participant 14-1.			
	& participants 14-3, 14-4, and 14-5	& participants 15-1, 15-2, 15-3, 15-4, and 15-5	& participants 16-1, 16-2, and 16-3	& participants 16-1, 16-3, 17-1, 17-2, and 17-3
Introduction	Pitch by the facilitators on BrusselAVenir and their methodology, followed by a presentation of knowledge they gathered on the topic from desk research and expert interviews			
How?	Oral brainstorming in pairs	Oral brainstorming in pairs	Creative writing	Cardboard prototyping
What?	Tram design	Experience design	Testimonials from future personas	Artefact crafting
Topics	The future of mobility	Experience of different tram stops & time of the day	Personal stories, conversations, and ambiance... People using the tram	Imagine life/space in and outside the tram
	The interior of a tram	Interaction with different neighborhoods		
	Tram staff & interactions	Entertainment & street performances		
Outcome	Mural drawing of the tram of 2030	Mural drawing of a future tram route & event plan	Six audio-recorded stories: Saïd, Mo, Elisabet, Josephine, Hicham, and Manuel	Five 3D objects made using cardboard: accessibility device, translation tool, tram stop, host-uniform, and performance stage

Note: <https://brusselavenir.be/>

Each workshop lasted for three hours, and after the fourth session, a small exposition was set up. All participants in the summer school were invited to participate in a short presentation on the process and outcomes of the Futures Labs.

Findings

The nature of knowledge

The goal of this research is to understand the generation, usage, and sharing of different knowledge types. The first step in the analysis was to identify and categorize the different knowledge types. An example of each knowledge type is provided in Table 2.

Table 2: Knowledge types observed in the case study

Knowledge type	Example from case study
Codified knowledge	The paper “The spatial distribution of open-street CCTV in the Brussels-Capital Region” (De Keersmaecker & Debailleul, 2016) was read as <i>desk research</i> in preparation for the workshop.
Articulated knowledge	<i>Oral presentation</i> given as introduction during each day of the workshop series (e.g., in 2030 Brussels, could be the cultural capital of Europe)
Encapsulated knowledge	BrusselAVenir created a <i>Persona toolkit</i> in which they processed a lot of the codified knowledge (e.g., the different registered nationalities of Brussels’ migrants) (see also Figure 2)
Tacit knowledge	A participant (14-4) shared a memory from a trip to Denmark: The driver’s seat is transformed into a playground for children because the tram is now automated.
Out-of-radar knowledge	Looking through the eyes of <i>fictional persona</i> Manuel: people transporting large items like a fridge on public transport

The use of different knowledge types

Prior to the workshop, much effort was put into gathering insights on the futures of Brussels, both from documents and expert talks. The facilitators digested this into a research wall showing (1) how citizens understand the topic of sharing the city, (2) what we currently know about 2030, (3) what is blocking us from sharing the city, and (4) best practices from other cities. Figure 2 shows part of this research wall, built out of pieces of text (e.g., statements or quotes) and visuals (e.g., cartoons or manipulated photos). The facilitators made several colorful connections between the pieces to trigger the viewers’ imaginations. Although one facilitator enthusiastically presented the research wall at the start of each workshop day, the information did not stick and was not used afterwards.

Furthermore, some media left more openness, provoking continued reflection or a response (e.g., the persona tool as guidance for writing a future testimonial), while others were more suited to closing or summarizing a discussion. A drawing as a conclusion (Figure 3) of the brainstorming during the first two days demonstrates how media can be used to promote convergence after a discussion.

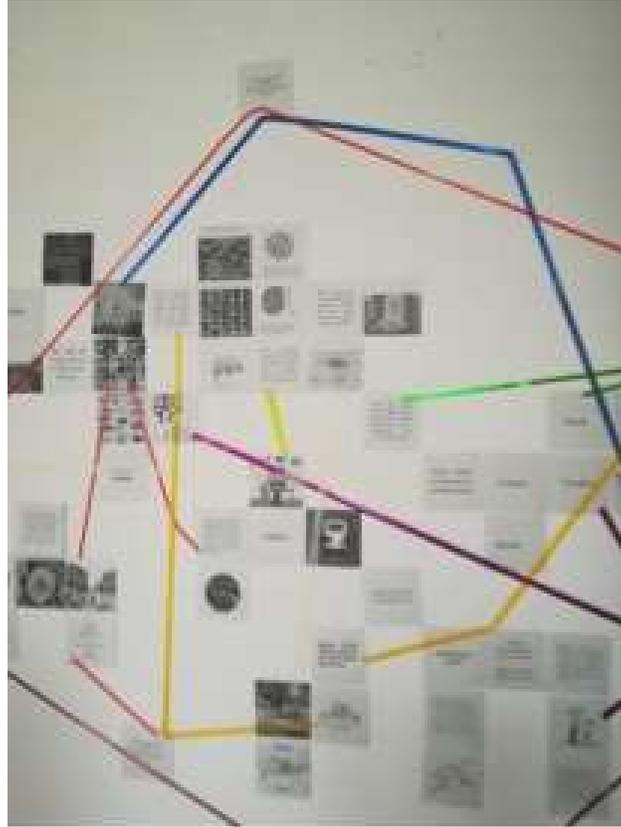


Fig. 2: Boundary object: Part of the research wall.

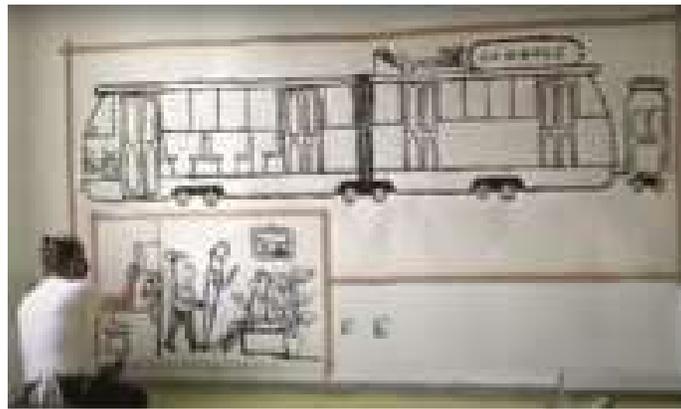


Fig. 3: Boundary object: The mural drawing of a tram in 2030.

The appreciation for tacit knowledge and its pitfall

"During the workshop, I learned the most from the organizers; however, the other participants inspired me most with their personal experiences and knowledge." (Participant 14-1)

The above quote illustrates the observed context of the workshops. When sharing thoughts in pairs or presenting the outcome of their brainstorming sessions, the participants mostly referred to what they had experienced themselves

(“As a woman alone, I do not feel safe in public transport in the evening,” Participant 15-1) or heard from others (“My father, as a child, went to school on the train without his parents,” Participant 14-4). Many anecdotes were shared, often without in-depth exploration. Still, the actors listened to each other carefully and appreciated their thoughts.

Only once (on day 1) a shared reflection led to a reframing of the topic, and thus, of the future vision. For example, Participant 14-4 mentioned how hard it is for people suffering from dementia to live spontaneously and take public transport. From that moment on, this neglected target group was included. Because of this predilection for tacit knowledge, present stakeholders should be as heterogeneous as possible or the voice of those who are absent should be added in a useful way. Furthermore, when asked to envision future situations, the participants tried to address their current frustrations. Hence, a mere exchange of perspectives based on anecdotes is insufficient for triggering high levels of future-oriented imagination.

Coping with lack of knowledge

In participatory futures workshops, it is common for people to be confronted with missing information. A clear strategy to address this must be foreseen by the facilitators: Are they aware of the missing elements, and how will they approach the situation when someone notices important gaps? In the case study, the facilitators provided information from their executed desk research—that is, codified knowledge. However, this knowledge was given prior to the brainstorming sessions before the participants were confronted with their unfulfilled answers.

Second, the BrusselAVenir team created a persona tool to represent a diverse group of city inhabitants. Through this intervention, they bypassed the absence of some citizens who were difficult to reach and motivated to participate in a workshop. This instrument brings additional points of view, enhancing the participants’ own tacit knowledge. Figure 4 shows part of the writing exercise performed on the third day of the workshop. While writing the story of a persona, some twisters were shared.



Fig. 4: Boundary object: Personal toolkit.



Fig. 5: Boundary object: 3D object in cardboard, language-translation device.

Third, according to the participants, during hands-on activities, some additional objective information (codified knowledge) was needed. Therefore, during the second day, the real itinerary of the imagined tram was searched for, and during the cardboard design activity (day 4), participants used Google for information (“We searched for the dimensions of a tram door,” Participant 16-1). When structuring a workshop, a curated pause to reflect on missing knowledge not only draws attention to important gaps but also stimulates the divergent thinking of the participants or augments their satisfaction.

Lastly, many aspects must be considered when imagining futures. These aspects may also generate a risk of losing oneself (e.g., in the creation of superficiality or in detailing one aspect). Correspondingly, the challenge tackled by BrusselAVenir is complex: The future of coexistence in a diverse city is interwoven with the future of mobility. These two fundamental topics are not completely independent. During the workshop, a hierarchy was given: The tram, an example of future mobility, acts as the medium to tell something about how different groups and individuals will share Brussels in 2030. However, during the workshop, a shift occurred, and a detailed future design of a particular tram (route) became the focus. The external illustrator/co-facilitator (14-2) formulated the following question in response to this shift: “If the public transport is just a medium, then why spend so much time designing the accessibility of the vehicle?”

Boundary objects

The drawings, the persona tool, or cardboard designs are examples of boundary objects. These tangible artifacts articulate knowledge that was previously not detectable in the context of the participatory workshop. Theory says that this encapsulated knowledge adds to the collective understanding of a (sub)topic (Boland & Tenkasi, 1995). Hence, we identified the different boundary objects and linked them to the present knowledge types (Table 3).

Table 3: Overview of observed boundary objects

Boundary object	Workshop day	Type of knowledge (K) encapsuled
Research wall (Figure 2)	Day 1 Day 2 Day 3 Day 4	Codified K (on sharing the city in 2030)
Illustration tram (Figure 3)	Day 1	Tacit and out-of-radar K (on trams, public transport, and spaces)
Illustration tram route	Day 2	Tacit and codified K (on public transport, on Brussels)
Persona toolkit (written writing guidelines) (Figure 4)	Day 3	Codified, tacit and out-of-radar K (on living and taking the tram in Brussels in 2030)
Persona testimonials (audio recordings of stories)	Day 3	Tacit, articulated and out-of-radar K (on living and taking the tram in Brussels in 2030)
3D objects in cardboard (Figure 5)	Day 4	Codified, articulated, tacit and out-of-radar K (on details of the tram in 2030)

We observed that most boundary objects served multiple functions. All provided the participants who missed steps in the development process of this participatory workshop with information. Furthermore, they were also shown at the workshops’ end to a broader audience. Aside from this, some boundary objects were used to stimulate actors’ divergent thinking, while others functioned more as a summary.

Second, we noticed that boundary objects often combined different types of knowledge. The use of codified knowledge does not exclude more subjective nuances from the actors’ tacit knowledge. As an illustration, prototyping is highly appropriate to intertwine different types of knowledge. This was demonstrated in the development of a language translation device for the tram (Figure 5). Although Participants 16-3 and 17-2 included information from the testimonial of Saïd (outcome of day 3), they also added their personal touch by choosing an eye-catching shape and creating sensorial experiences by including different fragrances for each tram stop.

Our findings on the dimensions of knowledge types and boundary objects are visualized in Figure 6. A river represents the workshop flow from start to finish. The stones in the river represent boundary objects. Their cores (different colors) represent the different knowledge types, and their edges represent the media used to communicate (e.g., drawing, story, or 3D object). Finally, the ripples around the stones represent their level of inspiration at a later moment during the workshop.

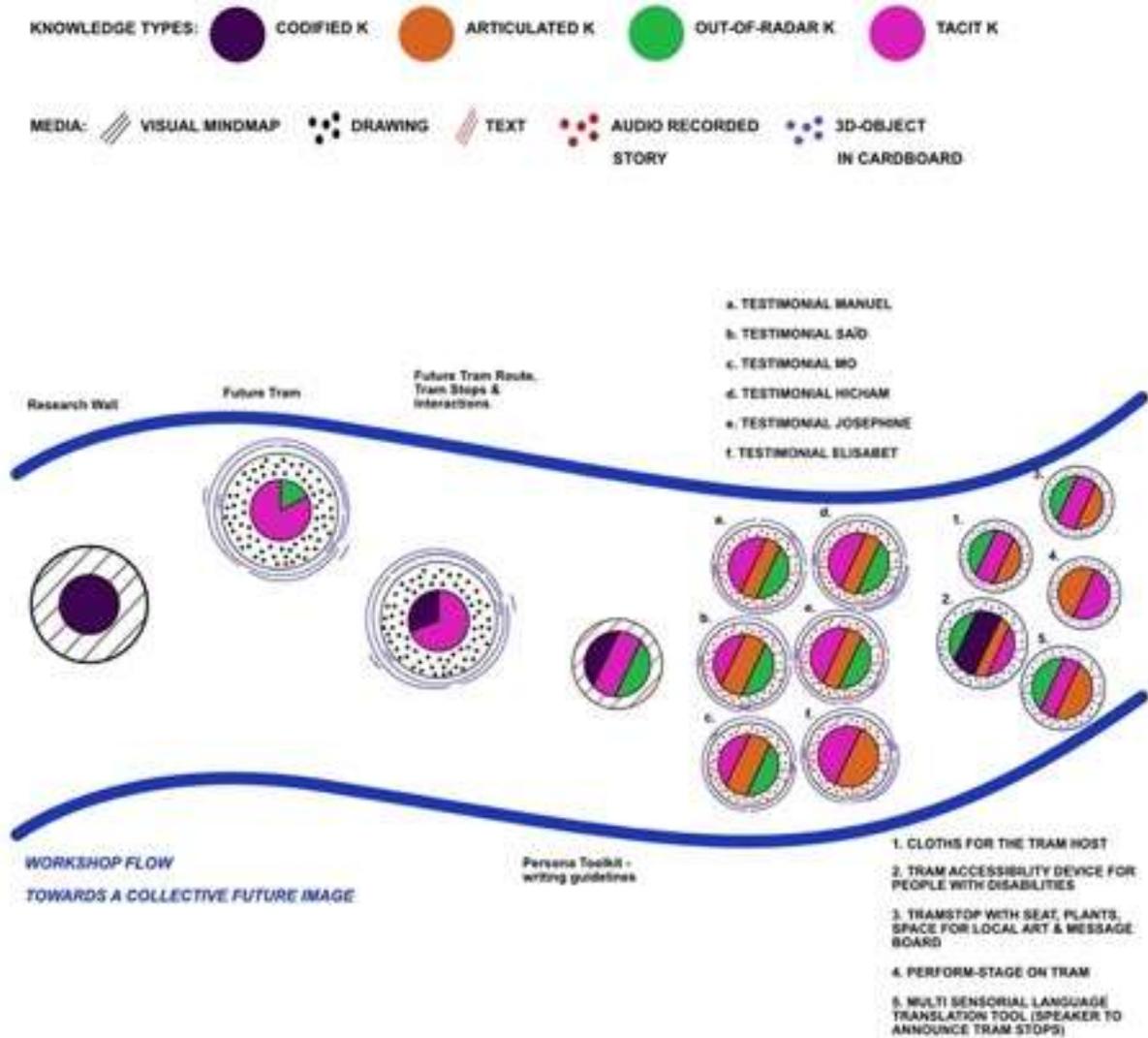


Fig. 6: Visual representation of the observed boundary objects in the activities flow of the case study.

Collaboration paradigm

The next step was to understand how the actors worked together and whether this had consequences for the transfer of information.

Unaligned goals

The main goal of the workshop, the project goal, was clearly communicated by the facilitators at the start of each workshop: “Shaping images of the futures that answer the question, ‘How will we share the city among each other in Brussels in 2030?’” Moreover, it was also their intention to present the workshops’ outcomes immediately after the last day.

Nevertheless, less obvious goals were also present. The first is the process goals of the facilitators:

- To trigger the imagination and conversation of the participants and audience (E and Kh)
- To teach the participants to work with cardboard with full confidence and let them make their own decisions

(illustrator J, or 14-2)

- To facilitate the smooth continuation of the different workshop days (E and Kh)

Second, some of the participants also had their own ambitions. Participant 15-1 wanted to draw more attention to the ideas of safety and well-being in our society and inspire her peers on the level of norms and values. Participant 15-2 was looking for more depth and diversity through the workshop, a desire that was not met. His personal goal was mentioned in the introduction to the workshop. However, in his post-workshop questionnaire, he expressed this disappointment.

Furthermore, sometimes, the goals conflicted. The smooth continuation of the four workshops required adequate introduction and wrap-up time, time the participants needed to tackle the topics critically and creatively. The chosen methods, which helped to articulate tacit knowledge or to come up with out-of-radar knowledge, were time consuming. Another issue is highlighted by the following quote:

"A participant shared sound ideas, essential information. But they were boring from my point of view as an illustrator." (Illustrator/co-facilitator J, 14-2)

When floating on the current made by tacit knowledge, whether confirmed by codified knowledge, disruptions from out-of-radar knowledge can feel threatening. Yet, sharper statements can trigger the imagination or stimulate a conversation.

Restrictions: Phases

Insights on the phases of the participatory futures workshops were collected and analyzed in relation to knowledge exchange.

A deliberate structure was adopted for the three-hour workshop sessions. An introduction on both the topic and methodology was first given. Because the workshops were consecutive, this introduction presentation was substantially longer on the fourth day than on earlier days. This risked compromising the progress of the subsequent activity where the boundary objects were created. A lot of information was shared, but this articulated knowledge from desk research should have been expanded with growing encapsulated knowledge (e.g., in drawings and stories). Co-facilitator J's (14-2) concern illustrates this: "Will there be enough time left for cardboard creating?"

Furthermore, each day was closed with a plenary reflection. This sharing moment was important in creating a feeling of satisfaction among all actors, since their points of view were heard. From here, the workshop facilitators selected what to transfer to the next session. As the brainstorming (days 1 and 2) did not result in a concise end product, participants struggled to find value in what was discussed for the next session. The drawings, which can be seen as a compilation of the brainstorming, were therefore not finished by the end of the workshops.

Nonlinearity

On the first day, two groups were brainstorming rather specific topics, such as the interior of a tram and tram staff and interactions, while one pair was still attempting to foresee a more general image of the future of mobility. A clear future-world framework wherein the participants could create implementations was lacking. The day-to-day results reflected a more applied level of specific experiences, interactions, and objects and failed to build a coherent and layered future image that visualizes leading values or trends.

The question remains: Would a (given) challenging abstract future setting trigger more out-of-radar knowledge? This approach might shape an opportunity for the use of imagination strategies. In the next section, the strategies employed are examined.

Imagination strategy

Imagination was an inherent part of each participatory futures workshop. In this section, we explore which approaches were taken to trigger the participants' imaginations and the influence they had on the workshop's knowledge flow.

First, different approaches triggered the participants' imaginations. Based on the chosen medium, the workshop activities can be divided into (1) illustration by drawing, (2) written testimonial, and (3) 3D objects of the futures. Another way to classify the activities is as imagination with or without-making. The participants were not drawing themselves. Instead, an illustrator drew on ideas that were selected by the facilitators and the illustrator himself. Conversely, on the third day, the participants wrote out "a day in the life of a (given) future persona." A similar situation was observed on the last day, with even more freedom for the participants to choose a topic and prototype how they envisioned it.

We noticed that imagination without-making, thus focusing on discussing, evoked mostly tacit knowledge from the participants, which they articulated easily while connecting such knowledge to current events or frustrations. Alternatively, when imagination with-making was triggered, in writing or prototyping activities, the participants processed (individually or in pairs) multiple types of knowledge in creating boundary objects (see Figure 6).

Second, the outcome of participatory futures workshops depended on how the participants opened themselves up and shared not only their experiences or current frustrations (instructive use of imagination) but also their dissenting associations and dreams (transcendent use of imagination). In the observed case, the participants stayed mostly close to reality, enabling tacit knowledge. Nevertheless, the persona toolkit challenged their empathic ability, which drove them toward out-of-radar knowledge. The idea of creating a collective entertainment experience on the tram for an interested public without disturbing those who prefer tranquility is an example.

Discussion

Understanding the complexity of forthcoming societal issues requires a collective and transdisciplinary approach (Bezerra & Brasell-Jones, 2005). Bringing stakeholders with different perspectives together to imagine future obstacles and opportunities is an applied approach that is increasing in importance (Heino, 2021). However, while we know that interactions between these stakeholders generate knowledge, how this knowledge process unfolds is not clearly understood. Therefore, in this section, we share our understanding of the dynamics of knowledge transformation in the co-development of futures. Our findings were gathered from an in-depth case study based on an analytical framework consisting of five dimensions: (1) the nature of knowledge and (2) boundary objects, (3) the collaboration paradigm and (4) restrictions as part of workshop methodologies, and (5) applied imagination strategies.

Moore and Milkoreit (2020) suggested that participants' comfort with foresight activities can be ensured by their imagination capacity. In addition, we found that evoking tacit knowledge increased the feeling of comfort. Moreover, the literature argues that increasing the diversity of views and handling unknown factors make the challenges of the future more complex (Lakhani & Panetta, 2007). Nevertheless, we propose that discussing today's unknowns helps in envisioning less obvious paths for the future. The creation of boundary objects and the time taken here can enrich this reflexive process (Star & Bowker, 1999).

Dufva and Ahlqvist (2015) and Mortensen et al. (2021) mentioned that spontaneous interactions are the most appropriate way to observe the transfer of tacit knowledge between participants. However, our data showed that this exchange can also be done through guided assignments. For example, when personas act as boundary objects containing tacit knowledge (i.e., original and personified), the message is easily transferred. However, a persona tool only provokes out-of-radar knowledge when it has the right balance between offering guidance and freedom to participants.

Furthermore, Boland and Tenkasi (1995) and Islind et al. (2019) elaborated on the open character of narratives as boundary objects. While they emphasize their question-generating strength, stories are equally valuable in closing a divergent phase and merging several elements together into (intermediate) outcomes.

On the topic of imagination, Miller (2018) advocated a two-track approach: not exclusively focusing on the materialistic aspects of a future world while also encouraging participants to add an emotional layer. Thus, the transcendent use of their imagination is challenged, which results in the production and sharing of more out-of-radar knowledge. Furthermore, (imagination with) making can distract from mental processes, such as meaning-making. This is in line with Zittoun and Cerchia (2013).

Regarding the practical contributions of this research, we refer to the metaphor of throwing stones in a river

(Figure 6) and cluster our recommendations into four learnings as follows.

How the river flows: A dynamic process

The balance between delineation and openness, in terms of the content and duration of workshop activities, is key. Although the facilitators should keep track of their goals, the participants' agency should also be promoted. This gives them a sense of control and augments their motivation. Thus, the facilitator should be able to spontaneously decide on the degrees of freedom that they allow the participants. Furthermore, through the supportive and challenging learning experiences gained from carefully planned divergent and convergent activities, facilitators can help participants become reflective and collective futures imaginers.

How each core of a stone is unique

At the start of each interaction, two-way focused introductions aligned participants through the sharing of impressions. This tacit knowledge increased the participants' empathy. However, in participatory futures workshops, staying close to the here and now is also a pitfall. For example, when actors only discuss their current frustrations or share anecdotes, little room is left to explore the underlying ideas. Framing or backing tacit knowledge with other types of information strengthens their meaning.

How the edges of stones determine their salience

A medium can equally trigger different knowledge types. For example, a template can combine different knowledge types or enclose imaginative elements into factual stories. However, this medium only adds value if it maintains its temporary and transfer status. On the contrary, when it gets too much attention, it can cause noise and diversion from the intended goal. This is the case when actors lose themselves in detail instead of increasing the communicative value of the medium.

How some stones leave ripples in the water

Finally, some "stones" have the potential to be inspirational but fail in their effect. For instance, a solid introduction contains the right amount of information. Too little information confuses the actors while too much information might not be absorbed. However, while boundary objects seem to have no influence at first, some of them appear afterwards in an indirect way when the participants have time to process the information or link it to their own. For example, in the project, it was observed that participants who joined all workshops were able to incorporate previous ideas that were not selected (and presented) by the facilitators. Therefore, it makes sense for the facilitator or the participants to expressively recapitulate from time to time what has been shared, with an emphasis on their reframing and changing assumptions.

In conclusion, we share some reflections developed together with BrusselAVenir after a series of workshops:

- The choice to converge brainstorming into a drawing (days 1 and 2) led to the consequence that contradicting thoughts had to be merged into a shared conclusion. In earlier BrusselAVenir workshops, these contradictions could coexist more naturally. Furthermore, having their outcomes drawn by someone else made the participants rather passive at the final stage of the brainstorm. Nevertheless, the visualizations as a summary were considered inspirational for the subsequent steps. Perhaps drawings could have been done during the divergent phase of the brainstorming while visualizing several options. Additionally, the artist might have drawn the participants' ideas in a futuristic style or translated them into a futures context.
- We acknowledge the challenge of taking people out of their daily reality. Therefore, the input of the participants trended more toward social innovation (e.g., focusing on inclusivity or the problems Brussels is facing today). Several adjustments have been considered, such as showing examples of futures or more strictly defining the starting position of the brainstorms by adding a futures element (e.g., The tram is part of the festivities of 200 years of Belgium: Who celebrates this and how?). Furthermore, Facilitator Kh observed that the available futures insights, presented at the research wall, were not implemented. She wondered whether using a different approach, such as sharing evolutions per field (technology, economy, and politics), would be helpful.

- Facilitator E mentioned that sharing and the energy among the participants on the third day were highly inspirational. This motivated her to figure out how role-playing could also be included in the persona tool.

Limitations

Although the analysis is based on different data sources (e.g., audio recordings and a questionnaire), we are aware that we possibly missed some nuances when these were not shared at the moment of data gathering. Second, a well-known limitation of interpretive research is the directly involved position of the researcher as a “passionate participant” (Guba & Lincoln, 1994, p. 115). Although this is one of the advantages of this approach, it may also be a weakness, as a close relationship with the studied actors should not hinder the inclusion of all participant’s perspectives (Andrade, 2009).

Further research

Further research on the analytical framework is recommended. The roles actors play in the knowledge transfer process in a sixth dimension (e.g., the facilitator role or influencing others as opinion leaders) could be considered in future research (Thompson et al., 2006). Furthermore, additional studies on the methodology of participatory futures workshops could yield further insights into, for instance, the relationship between co-creating boundary objects and simultaneously generating encapsulated knowledge. Finally, a multiple case study would generate a broader appreciation of how knowledge is used, created, and shared within participatory futures projects.

Acknowledgements

Ellen Anthoni & Khushboo Balwani from BrusselAVenir and all participants of the workshops.

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