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When we talk about time, we mean many different things: employing visual mapping to think through more-than-human temporalities in participatory design

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In recent years, the scope of participatory design has broadened to encompass perspectives and approaches beyond the human realm. This expansion requires considering multiple aspects to fully capture 'more-than-humans' diversity and concerns. One approach to tackle this multifaceted challenge is by examining it through the lens of time. However, the temporal dynamics of more-than-human entities remain relatively unexplored within participatory design. This paper investigates the potential of visual mapping to aid stakeholders engaged in participatory design processes that incorporate more-than-human perspectives in navigating the complex dimensions of more-than-human time. The findings demonstrate how visual mapping can facilitate thinking beyond linearity, developing awareness of workshop-related temporality, making time concrete, understanding the 'far lense' through the 'near lense', comprehending time's relationality, unfolding time and considering multiple timespans simultaneously. Based on these findings, the paper suggests that visual mapping can help understand more-than-human temporalities in participatory design by thinking through them as a reflective practice.

KEYWORDS

participatory design, more-than-human, temporality, visual mapping, visual communication, research through design (RtD), non-anthropocentric design

1 Introduction

In recent years, due to the global environmental crisis and the realization that design plays a decisive contribution to climate change and the ongoing extinction of other species (Wakkary, 2021; Laurien et al., 2022), participatory design has started to embrace entities such as rivers, forests, weather systems, animal flocks and viruses as subjective and political actors. The idea of multi-species justice (Celermajer et al., 2021) and the understanding that human existence is intertwined with the lives of other beings (Haraway, 2016) enable the emergence of new relations and dynamics in the participatory process from a position of humility and care (Akama et al., 2020; Bridle, 2022), paying attention for more-than-human entanglements and interdependencies (Laurien et al., 2022).

Involving more-than-human actors in participatory design processes requires considering multiple aspects, including their "diversity, disagreements and overlapping concerns" (Wakkary, 2021, p. 212). Capturing the full complexity and multifold dimensions of more-than-humans is an overwhelming task. Smitheram and Joseph (2020) argued that to expand a more-than-human approach in participatory design, we must consider different ontological perspectives and emergent methodological approaches. One way to address it is through the lens of time (Rose, 2012). Considering multiple temporalities related to more-than-human actors - such as the generations of living things, ecological time, synchronicities, intervals, patterns, and rhythms (*ibid*), expressed in, for example, "the turning of the seasons, the continental migration of birds, the lifespan of trees and plants" (Bridle, 2022, p. 118) - can facilitate understanding their perspectives and context of life (Mareggi, 2013), and enable us to understand more fully design processes grounded into the complexity of these ecosystems.

However, we seldom think through temporal diversity (Rose, 2012). Del Gaudio et al. (2017, p. 114) point out that "participants and space have often been the subject of research activities, while time has always received far less attention." Saad-Sulonen et al. (2018, p. 5) relate to temporality in participatory design by saying that, although such interest exists in numerous other fields (e.g., organizational studies, anthropology and interaction design), participatory design is "still far from having an established time-sensitive discourse."

In this paper, we will explore how visual mapping can help stakeholders involved in participatory design processes that embrace more-than-human perspectives to think through multiple dimensions of time beyond the human and understand their relationality. We see 'thinking through' as a reflective practice aiming for a more thorough and careful understanding and entailing a sense of directionality, a closer engagement with materiality and a more nuanced, detailed and multilayered view of time. As such, the idea of 'thinking through' can be considered as opposed to routinely schematic and reduced considerations of time, which take into account already familiar knowledge. Our study is grounded into some design experiments in the form of participatory design workshops, which were carried out between 2023 and 2024 in Denmark and Sweden.

The structure of this paper will be as follows: In Section two, we review existing literature according to the categories 'visual mapping', 'temporality in participatory design' and 'more-than-human perspectives in participatory design'. Section three explains the methodology in use. Section four presents the workshops' main findings. Section five contains the discussion and articulates the paper's main contribution. Section six presents some final remarks.

2 Literature review

2.1 Visual mapping

This paper departs from the map definition as "a diagram or other visual representation that shows the relative position of the parts of something" (Merriam-Webster Dictionary, 2024). The first part of this interpretation highlights the depictive role of the map as an artefact and its function as an output. Its second part articulates the maps' fragmental and relational quality. Examples of such maps used in design processes are actor-network mapping (Morelli and Tollestrup, 2007), which provides a broad overview of the network of actors and components in the system, context mapping of social, cultural, environmental and economic realities by local knowledge holders (Sarantou et al., 2021), time-based diagrams (Sevaldson, 2004), which show action sequences in service, and motivation matrices, which display the functional relationship between all the actors participating in a production system (Morelli and Tollestrup, 2007). These maps generally function as a rhetorical device (Propen, 2007) to convey a message.

Other visual mapping techniques associated with this definition aim to capture a higher level of complexity by emphasizing multiple parts of the depicted topic and acting as analysis tools (Doyle et al., 2024). Thus, they can serve as a boundary object to facilitate research (Harvey, 2024) and unfold different problem dimensions (Irwin, 2015). Examples are mental model maps that make implicit knowledge visible (Doyle et al., 2024), Giga maps (Sevaldson, 2011), which frequently serve as a repository of information, giving stakeholders access to existing knowledge across multiple layers and scales, examining relationships between categories, and critically framing the system (Jones, 2014), or synthesis maps (Jones and Bowes, 2017), which incorporate multiple layers and scales into one visualization. Designers use these maps to synchronize and coordinate a situation from a multistakeholder perspective (Harvey, 2024), articulate relationship configurations, amplify plurality, and elaborate complexity. Therefore, they could be read in various ways and do not convey a single message.

In this paper, we focus on visual maps created and used in participatory design. Both 'participatory' and 'visual mapping' refer to well-established disciplinary frames. However, brought together, they give rise to a different practice mode. Yet, the term 'participatory visual mapping' is not consolidated in design literature and practice, and the few mentions in the literature mainly relate to various visualisation techniques. For example, within the context of participatory design, Gaudion et al. (2015) use visual mapping and photographic imagery to design questionnaires; Vrancken (2018) employs it when describing a figure to represent soil diversity, and Buur et al. (2013) consider it when describing a value flow model created to support a team discussion. Visual maps used in participatory settings are often process-oriented, unlike maps that function as outputs and are often characterised by compelling visual images with rhetorical power (Kitchin and Dodge, 2007). These process-oriented maps focus on mapping as a practice of shared thinking that stakeholders use to explore and construct conditions and relations, aiming to reach a more nuanced understanding of complexities by creating spaces for conversation, augmented sensorial awareness and explorations (Pollastri et al., 2021). As such, they are not fixed but in a constant state of becoming (Kitchin and Dodge, 2007; Dodge et al., 2011). In this map type, the distinction between production and application, producer and user, is blurred (Grootens, 2021).

To suggest a more nuanced understanding of the different types of mapping, we turn to the paper Visualisation and Cognition: Thinking with Eyes and Hands by Latour (1986). Latour allows us to look closely into the purpose behind the act of drawing things

together, which we interpret here as 'participatory visual mapping' and points out two approaches to mapping by telling the story of the French explorer La Pérouse, who travels through the Pacific to bring back a better map. During this journey, La Pérouse arrives at Sakhalin in China and tries to learn from the locals, whether it is an island or a peninsula. To help him, an older man draws a map of his island on the sand with the scale and details that La Pérouse needs. A younger person sees that the rising tide will soon erase the map and picks up one of La Pérouse's notebooks to draw the map again with a pencil. Latour discusses the differences between the two maps. He concludes that what is, for one, a drawing of no importance that the tide may erase is, for the other, the object of his mission. The older Chinese person, he writes, does not have to keep track since he can generate many maps at will, being born on this island and fated to die on it. La Pérouse, on the other hand, is just an occasional guest aiming to visit and take something back and, therefore, needs the map as a portable object.

The first approach to mapping is situated, temporal and process-oriented. The Chinese person creates the map to answer a question. He does not consider it an object meant to last or function outside the encounter. Therefore, he uses materials from his immediate environment to facilitate a conversation and does not care for them to last. The temporal frame is present, responding to *ad-hoc* needs and subjected to the earth's rhythm. In contrast, the young man is interested in mobilising the information for the future and sharing it with others outside of the momentary encounter. To do so, his artefact must contain "absent things presented all at once" (p. 8). Latour explores this proposition, providing us with instructions for what we could consider a visual communication approach to map-making: "The "things" you gathered and displaced have to be presentable all at once to those you want to convince and who did not go there. In sum, you have to invent objects which have the properties of being mobile but also immutable, presentable, readable and combinable with one another." (p. 7). The map created by the young man becomes a vehicle to stabilize and transfer knowledge into new contexts and further time.

Through the story, Latour explains maps' traditional visual communication role as a "transferable form of knowledge that is portable across space and time" (Kitchin and Dodge, 2007, p. 15). Thus, maps can enable actions at a distance and consolidate information to become part of Western scientific knowledge aiming at making true claims about the world (*ibid*). Nevertheless, Latour recognises that a different approach also exists by mentioning alternative ways of mapping. Indeed, 40 years after he wrote this text, participatory design adopts this proposition by approaching mapping as a situated, momentary, and relational practice (Kitchin and Dodge, 2007). In practice, designers tend to blend the two approaches to co-create situated knowledge and share it with others outside of the momentary encounter.

This is also the case when mapping multiple temporalities. Hayes et al. (2021) invited participatory designers to capture and combine differing temporal perspectives in a final design outcome. They highlighted the importance of articulating them visually, allowing the views to correspond to each other to provide opportunities for mutual learning, knowledge exchange, discussion, testing, and design. Similarly, Pschetz and Bastian (2018) called for designers to create artefacts and systems that disclose the variety of temporality and temporal relationships. However, the view of visual mapping as an approach to support thinking through time is generally overlooked.

2.2 Temporality in participatory design

So far, the research on temporality in participatory design has been carried out from a few angles. The first is project time (Saad-Sulonen et al., 2018). Lindström and Ståhl (2015) discuss design as entanglements in multiple temporalities during and after the project. Farías (2017) explains how project timelines create certain norms and values. Del Gaudio et al. (2017, p. 116) point out how temporal misfits might be a common situation in participatory design because "each actor's time and specific regulations may strongly influence the project's global time and respective temporal dynamics" and therefore suggest considering temporal aspects such as "local rhythm, the time required for achieving change, community participation speed and timing norms of partners."

Another angle relates to participation: (Hayes et al., 2021, p. 509) call for considering the multiplicity of temporalities among participants and "taking the temporal flow of participation into account more actively." Saad-Sulonen et al. (2018) propose five lenses that may aid researchers in exploring and understanding the temporal dimensions of participation: the phasic, emergent, retrospective, prospective, and long-term lenses.

Participatory design also approached temporality from the perspective of extending the time lens. Here, design researchers try to stretch the participation view, including looking back, forward and more extensively into the present (*ibid*). Wakkary (2021, p. 67) relates to extending temporality into the future in participatory design through the notion of artifacts as they "operate across time from the present to the future." Thus, understanding the use of a present artifact is the analytical grounding for an imagined future use of a related artifact, assuming a continuation. Laurien et al. (2022) emphasized that many issues cannot be solved during the project's time frame or perhaps not even within a human lifetime. Few scholars dedicated special attention to the past, suggesting how working with it in the context of social-life timing (Del Gaudio, 2023) can contribute to the design process (Huybrechts and Teli, 2020; Kambunga et al., 2023; Zuljevic et al., 2023). Jönsson et al. (2021) suggested situating the problem of out-of-sync plant-pollinator relationships into a rich present rather than a distant future as part of what they call 'collaborative future-making'. Jönsson and Lindström (2022) articulated change in relation to the past so we can orient ourselves towards unknown futures. Despite these existing studies, scholars point out that participatory design research did not pay much attention to temporality aspects (Saad-Sulonen et al., 2018; Del Gaudio, 2023), temporalities are often left under-specified (Søndergaard et al., 2023), and there is still much room to go beyond traditional time dichotomies (Rapp, 2022).

Moreover, the existing time-oriented discourse in participatory design is mostly limited to a human-centered perspective and is mainly based on the related (human-centered) social and cultural context. Del Gaudio et al. (2017) defined four social-related categories of temporality in participatory design, and Pschetz and Bastian (2018, p. 171) suggest a temporal design approach to bring "cultural, social and economic aspects of time to the surface." An exception is the work

of Laurien et al. (2022), who argued that a more-than-human perspective should drive designers to work with multiple temporalities. In their work, they explored the notion of deep geological time and broadened the temporal perceptions of their participants to include the present and speculative future. Hayes et al. (2021) pointed out the need to develop an 'attunement' towards different temporalities existing in the participatory design process as they generally remain under study.

2.3 More-than-human perspectives in participatory design

The history of participatory design is human-oriented. It emerged in the 1970s in Scandinavia from systems design to counteract the dehumanising effects of an increasing technological presence in the workplace (Ehn, 2008), with the intention to involve and empower a broad range of stakeholders in decision-making processes as co-designers (Lindström and Ståhl, 2015; Wakkary, 2021). Over the years, participatory design has shifted towards sustaining and developing communities of participants exchanging skills and knowledge to arrive at a process of designing together and addressing their concerns (Wakkary, 2021). Methodologically, participatory design often uses workshops, interventions, art-based methods and prototyping to facilitate participation in the design process (Jönsson et al., 2021; Pietarinen et al., 2023). As part of its inclusive approach, participatory design promotes the involvement of people without a voice and power, e.g., from marginalized and vulnerable groups like youth, people with dementia, autism and others (Akama et al., 2020; Pietarinen et al., 2023).

In recent years, issues like climate change, biodiversity loss, and increasing extinction rates have created conditions for explicitly including nonhumans on the participatory design agenda (Bastian, 2017), responding to Latour's (2004) opinion that both humans and nonhumans have the right to speak. Participatory designers have increasingly reflected on expanding participation to incorporate more-than-human actors' perspectives in design processes (Haldrup et al., 2022), acknowledging that human and non-human actors have equal agency (Miettinen et al., 2022). However, how to understand the relations between humans and more-than-humans is under debate. Some participatory design streams tend to contrast the two groups (Andersen et al., 2015). Rice (2018), for example, distinguishes between humans, who can take actions affecting something, whom she defines as participants, and more-than-humans as "entities that do things," which she relates to not as participants but as 'actors'. A different approach, represented by design researchers such as Akama (2015), Laurien et al. (2022), and Romani et al. (2022), perceives participatory design as a discipline that should alter the boundary between participating and 'not' participating in a non-hierarchical manner. They emphasized our relations, inseparability, and entanglements with more-than-humans and question the context in which the exchange of ideas and interests happens (Sachs Olsen, 2022). Fundament to this debate is the issue of language. Bennett (2010, p. 107) suggested "loosening the tie between participation and human language" to encounter the world "as a swarm of vibrant materials entering and leaving agenic assemblies." Other researchers explored the participant's role as a 'spokesperson' (Sachs Olsen, 2022) or 'speaking subjects' for and on behalf of nonhumans (Wakkary, 2021).

To date, participatory design researchers explore more-than-human approaches from three main angles: methodology, materiality and participation. From a methodological perspective, Laurien et al. (2022) stress the importance of embodiment as a bodily and sensorial engagement, also present in the work of Haldrup et al. (2022, p. 15), "draw from sensing, observing and doing." Artistic and aesthetic representation that showcases and represents what we cannot see is another methodological approach presented in their work and in the research of Sachs Olsen (2022). The equipment and materials used as design tools, identified by Laurien et al. (2022) as a core denominator connecting design and more-than-human approaches is the focus of other researchers (Rice, 2018). A third stream of research focuses on more-than-human participation, like in the case of Laurien et al. (2022), who substituted pollinators to indicate their potential future absence in the pollination of clover plants. Nevertheless, more-than-humans have been relatively under-researched in participatory design, and the focus remained largely human-centered (Palmås and von Busch, 2015; Clarke et al., 2019).

There is an agreement among participatory design researchers that expanding more-than-human approaches is much needed for the sake of the field itself to develop a fuller understanding of participatory design (Rice, 2018) and as a means towards more significant goals such as forging our thinking and practice (Akama et al., 2020), to create "more democratic networks, formulate non-hierarchical relations, and, consequently, reflect on the more-than-human agencies and interests" (Romani et al., 2022, p. 2), "re-enchant" the commons and "pose environmental justice claims" (Haldrup et al., 2022, p. 15), and understand the impact of participatory design on more-than-human actors (Calderon Salazar and Huybrechts, 2020). Among the various more-than-human perspectives yet to be explored in participatory design is the aspect of temporalities. As discussed here, there is a lack of studies that connect participatory design, temporality and more-than-human. Thus, this paper will address this question: How can visual mapping support understanding more-than-human temporalities in participatory design?

3 The methodology

This paper is grounded in research through design. The core of research through design includes three components of the iterative work process: formulating a program, realizing through experiments, and formulating results through reflection (Redström, 2011; Löwgren et al., 2013). Binder and Redström (2006) see the program as the first framing of a design space within which possibilities can be explored through experimentation. Brandt and Binder (2007) define it as a "hypothetical worldview that makes the particular enquiry relevant." Converging the two aspects, the program refers to a set of overall intentions and aims to guide a possibly extended explorative design process (Redström, 2011; Löwgren et al., 2013).

The program depends on experiments to substantiate its propositions or proposals. In other words, it needs materialization to

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TABLE 1 An overview of the workshops.

Workshop no.	Location	Duration	Participants	Visual mapping techniques in use	Number of participants
1	The South Harbour, Copenhagen, Denmark.	5 hours	Design students	Group Flipboards, sketching, photos, strings	26
2	Folkparken, Norrkoping, Sweden.	4 hours	Design researchers	Shared canvas, Objects from nature picked by participants and organisers, photos, sketching	9
3	Amager Fælled, Copenhagen, Denmark.	3 hours	Architects	Shared canvas (outdoors), Objects from nature picked by participants and organisers, photos, sketching	4
4	Hybrid Workshop in Malmo, Sweden. Including online participants from Denmark, Turkey, Finland and Portugal.	5 hours	Scholars working with more-than-human approaches	Sketching, shared canvas on Miro board	11
5	The South Harbour, Copenhagen, Denmark.	5 hours	Design students	Sketching, group canvases, Organic materials: wooden bricks, soil, wood, bulbs, water	18

FIGURE 1
Tuning with the environment. Upper left corner and clockwise: Folkparken, Norrkoping, The South Harbour, Copenhagen, Amager Fælled, Copenhagen, Malmo Harbour.

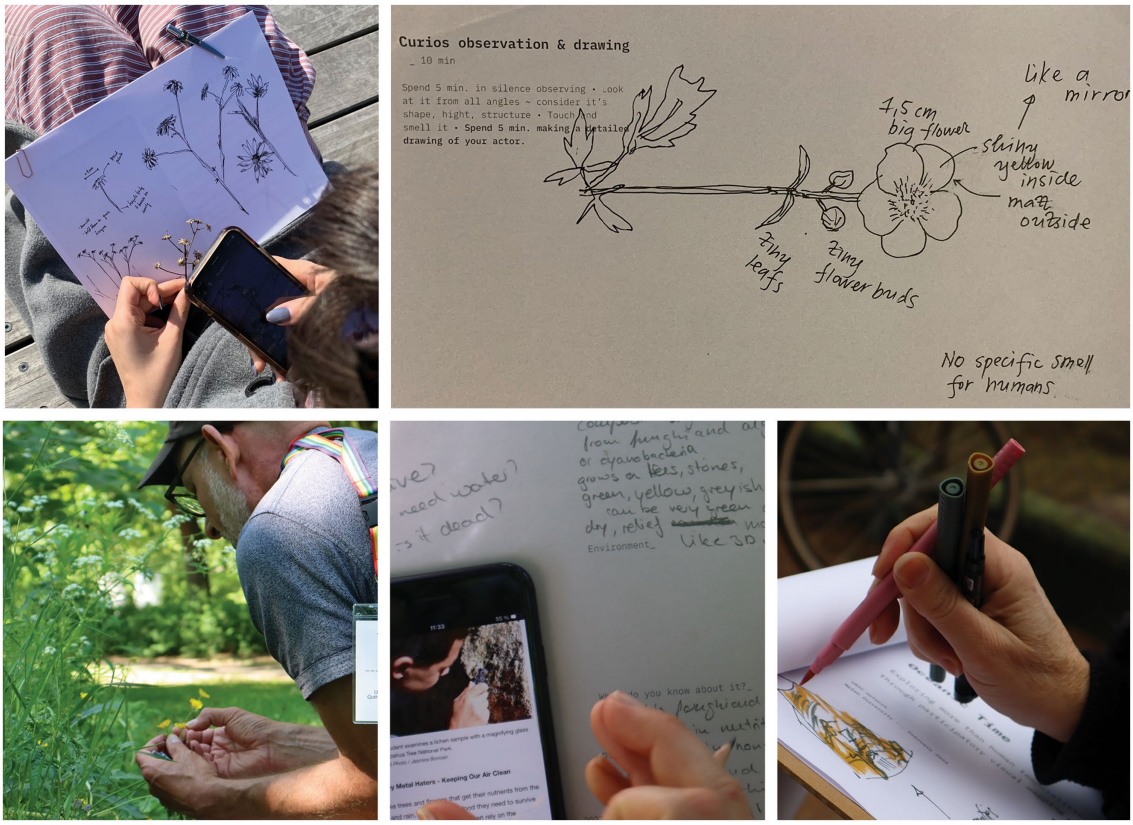

FIGURE 2
Exploring a specific actor.

make its hypothetical worldview into something 'real' (Redström, 2011). At the same time, the experiments need the program as a precise frame to provide intention and direction and ensure everything 'falls in place'. These are dialectic relationships. The experiments respond to the program's suggestion as explorative actions and form certain insights that, through reflection, make sense of early intuition and reframe the program to comprise new experiments (*ibid*). The experiments also serve as a vehicle for theory construction and knowledge generation (Bang and Eriksen, 2019).

The program described in this paper comprises five experiments in the format of workshops. Each workshop was guided by one to three facilitators, including the authors of this paper and their colleagues. The workshops took place between 2023 and 2024 in Denmark and Sweden, with 68 participants (Table 1). The initial framing of the program started from an educated intuition aiming to explore and represent more-than-human perspectives in participatory design. In early experiments, the temporal aspects were among other aspects that we explored with participants. As our research advanced, the reflections made us realize this topic was particularly interesting and we formulated the program centering the later experiments around it.

All five workshops followed a similar structure: the first part occurred in an urban outdoor area where we guided the participants through what Tsing (2015) calls the "art of noticing." In this part, we tuned in and developed attentiveness to the environment to become more sensitive and better capable of seeing, hearing, tasting, and feeling (Mol, 2010) and approach the workshop as an informal experimental space (van Dooren et al., 2016). To do so, we guided the participants through several exercises, including a listening meditation session and various forms of observation, where they took notes, picked local materials and drew sketches to collect their impressions (Figure 1: Tuning with the environment). In the case of the hybrid workshops, participants followed these activities using a digital booklet that included written instructions and audio guidelines. Then, we asked participants, individually or in groups, to pick a more-than-human actor or assemblage, observe, interact and explore it through another sequence of exercises, including curious observation and drawing, exploring actors' environment, conducting rapid online research, drawing actors' time and writing a letter to the actor in the future (Figure 2).

In the early workshops, we addressed the temporal aspect by relating to the actors' lifespan and time, writing a letter to the actor in a 100 years, and imagining what came before by drawing a timeline from the beginning of time until now. In workshops four and five, we focused on the temporal aspect, asking participants to depict actors' time through three temporal categories: actors' time in relation to the natural world, considering aspects such as seasons, tide, light and astronomy, actors' lifetime and pace. To facilitate the exercise, we asked participants probing questions such as: Is time linear or circular? In which direction does it move? Does it move at all? Is it a developing or a still situation? On which scale do you measure it? What can interrupt it?

FIGURE 3
Some of the materials we provided the participants to support the visual mapping.

FIGURE 4
Visual mapping sessions.

In the third part of the workshop, we provided participants with various materials (Figure 3) and a canvas to create a representation of the actor they interacted with. In the first three workshops, we ran a visual mapping session in which we visually represented the actors we interacted with, drew their relationships, and concluded with a discussion in which we reflected on our work. In the fourth workshop, we gathered for an online session where we shared the various temporal depictions we created on a digital Miro board, and on the fifth workshop, we asked groups of four participants to create a shared temporal depiction based on their earlier individual work (Figure 4). We concluded all workshops with a discussion among participants. As research showed that some dimensions of temporal judgement are more strongly associated with aspects of experiential perception, while others depend mostly on cognitive processes (Block, 2014; Correia, 2024), we aimed at combining the two to fully leverage participants' temporal perception. The evolution of the workshops' design was made possible through our ongoing learning from participatory observation in the workshops and from the participants' feedback.

4 Findings

The five workshops we described above expanded participants' awareness concerning several dimensions of temporality.

4.1 Thinking time beyond linearity

The workshop participants depicted time in various ways: linear, circular, and accumulated. In cases where time was pictured linearly, some sketches suggested fluid and fuzzy depictions, unlike common straight lines often associated with modern perceptions (Aigner et al., 2011) (Figure 5).

One participant reflected on how different forms can alternate with each other, saying: "As individuals, we can view our lives as linear, but if we add past and future generations, they become cyclic." Simultaneously, various other participants depicted time circularly (Figure 6).

Participants who interacted with the Creeping Buttercup flower noticed the time it was apparent above the ground and chose to represent it through the four seasons in a circular manner, not as an act of linear life and death but as a cyclical process formed by the seasons (Figure 6). A participant who observed seagulls (Figure 6) represented their lifetime as a circle of "growing, laying eggs that become young birds again." This made her reflect on the differences between the time experienced by the individual and species-related temporality, saying, "I realised this visualization is probably describing the species rather than a single seagull."

The interaction with a Water Lily (Figure 7) made participants think through seasonal time. She learned from a web search that Lilies grow under the water in the winter, but the observation made her

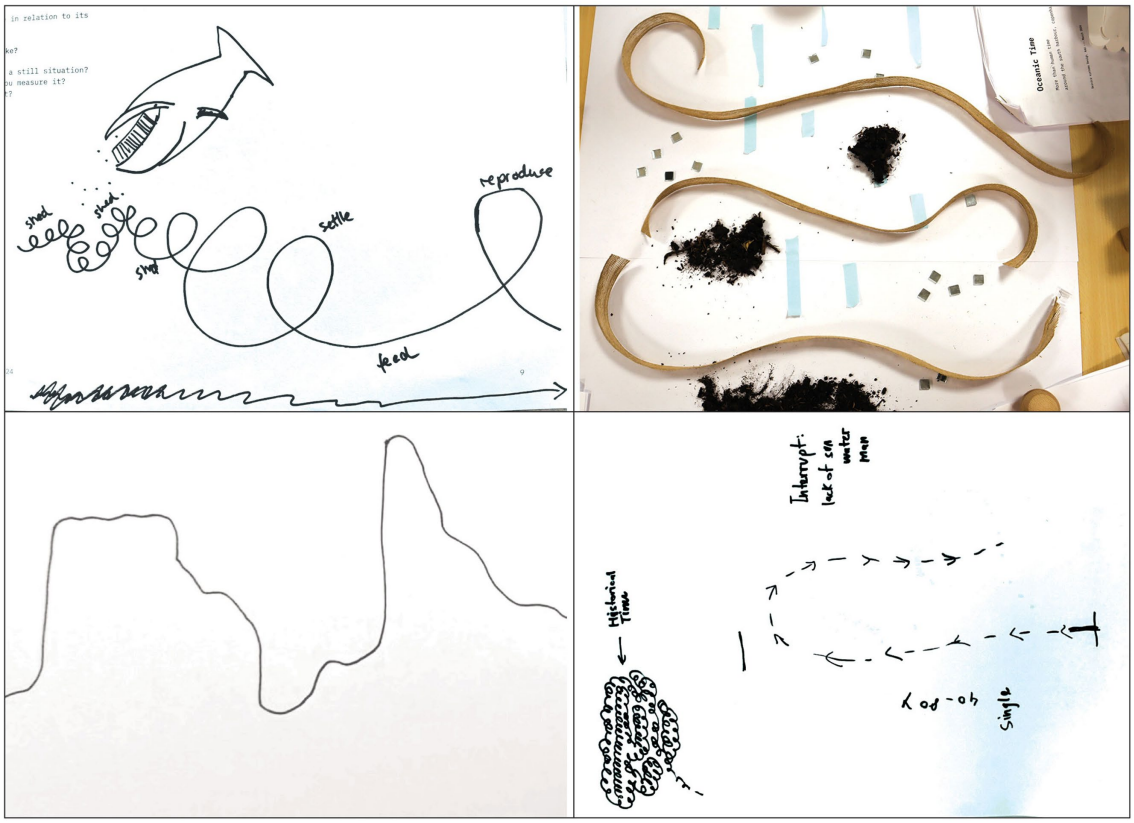

FIGURE 5
Upper left corner and clockwise: a linear depiction of time in relation to barnacles on rocks, algae, ice on soil and Weeping Willow tree.

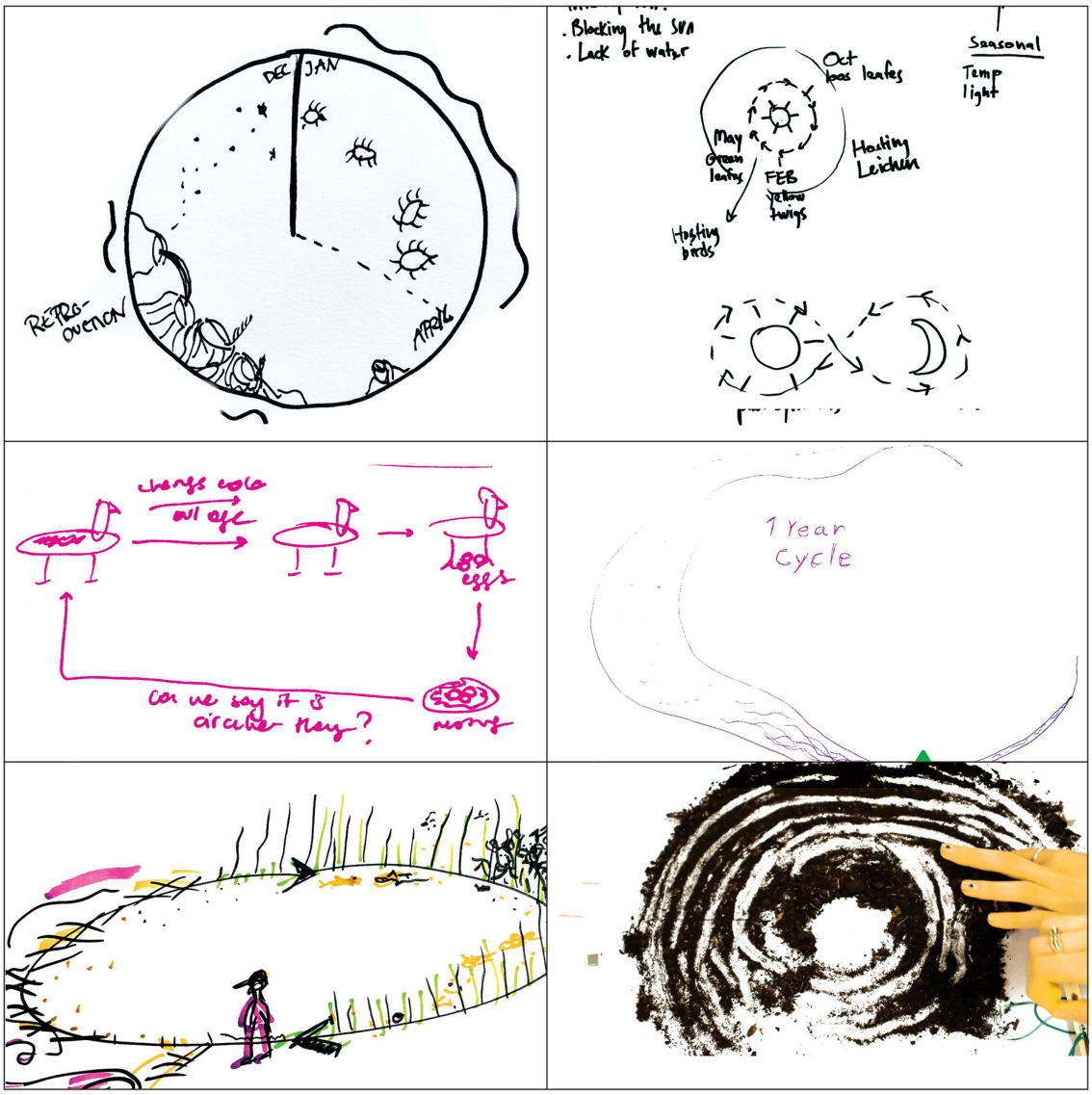

FIGURE 6
Upper left corner and clockwise: circular depiction of time in relation to barnacles, a Wipping Willow tree, a ditche, moss, *Phragmites australis* reed and seagulls.

FIGURE 7
Engaging with a water Lily.

reflect: "I cannot tell if it is the same leaf coming out every year or it is a new one after the old one dies." The participant was immersed in the interaction, trying to understand the Lily's mechanism through the lens of seasonal time.

A third mode of depicting time was accumulation (Figure 8). One participant mentioned that it is easier to relate to the circular time of other organisms as these are rhythms we share, whereas the accumulated time becomes more abstract. He added that it is also a matter of perspective and framing, as "the seasons also show themselves in accumulation: in rocks and tree rings." Another participant who depicted a time of a tower covered with moss related to the quality assigned with accumulation, saying: "It is like time falling into itself because it is so dense." A third participant reflected on the term accumulated time and suggested it can serve to describe growth in a regenerative manner since extracting from it will require a long period to reproduce.

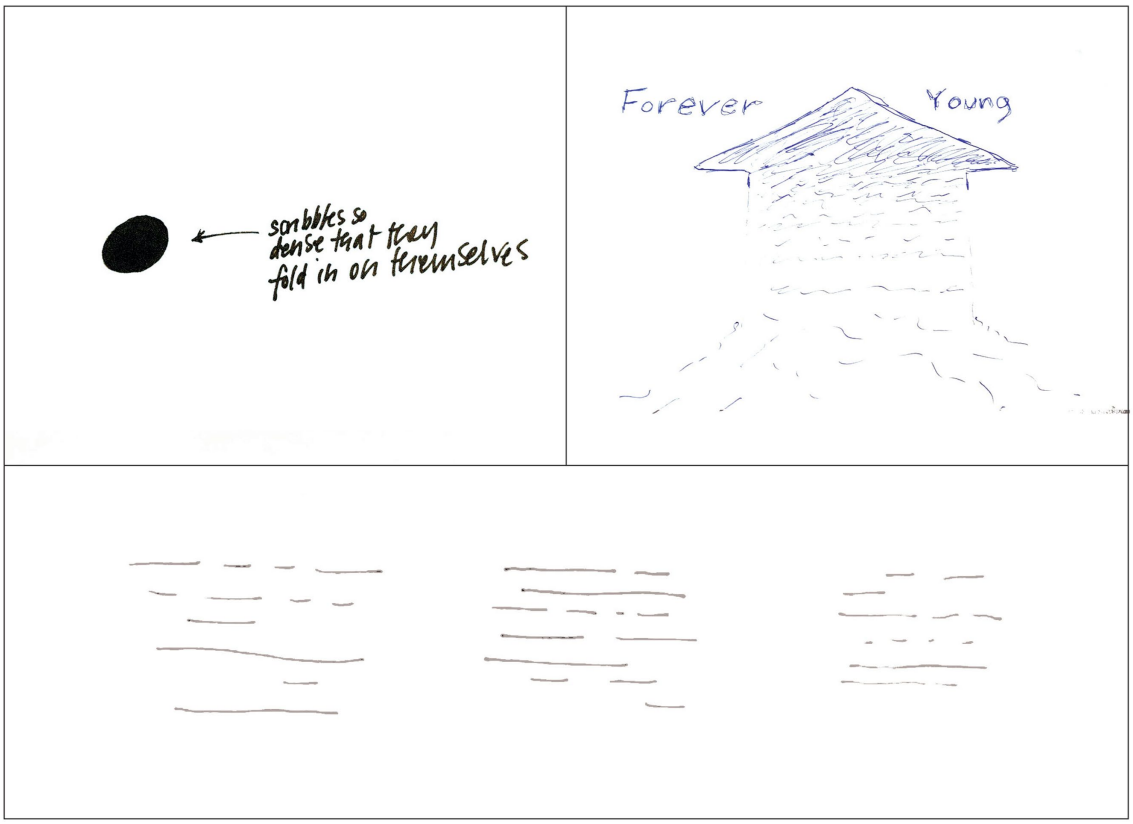

FIGURE 8
Upper left corner and clockwise: depictions of accumulated time in relation to a tower, white moss and ice on the soil.

4.2 Developing awareness of workshop-related temporality

Participants reflected on how temporality played out in the workshop setup. As each workshop lasted three to 5 hours, some said that creating a deep connection with other species requires more time and wished for a more extended engagement period, critically saying: "I wonder if quick workshops are a good format to understand these connections." Others hoped for a different interaction format to allow more time to connect, saying: "Imagine an ongoing workshop in one place for a long time…!." Another aspect of temporality in the workshop was the access to information on the participants' phones. One of the participants reflected that accessing the external stream of knowledge available on the web expands the workshop's scope beyond the here and now by including unlimited knowledge generated and collected over time. In terms of the nature and quality of their engagement, participants reflected that to notice multiple temporalities beyond clock time, one needs to change one's speed and slow down. Observing various temporal aspects such as seasonal time, stage of growth, and relations between different tempos can be reached when participants center within themselves and contemplate their surroundings. Figure 9 shows how the act of sketching facilitates and reflects the attunement to the environment by noting down small details that people commonly overlook, such as the leaf's shape, shadow on the ground or sound, and enhancing it by forcing the participant to pay close attention to details they can otherwise miss.

4.3 Making time concrete

Augustine et al. (2019) pointed out two common ways to discuss futures. The first is called 'distant futures', which are construed more abstractly and tied to broader theories, ideologies, and desired identities. The second is near futures, which are detailed and connected to sensory observation and the degree of practicality, interpreted in more specific terms and with more detailed situational elements. Augustine et al. encourage specificity and credibility as, according to them, they are assigned to a sense of plausibility and seriousness rather than mere fantasy.

While presenting the interaction with more-than-human actors and reflecting on the mapping exercise, we often apply the 'distant futures' approach by making generalizations about time and imagining more extended periods than the actual time. For example, participants assumed that the river slopes "has probably been there for millions of years" and can last forever, the oak "has been here longer than all of us, and it has been through a lot," the Creeping Buttercup flower "can stay yellow forever," and moss is "'forever young." In relation to a tower dated to 1940, a participant mentioned that "it sits out of time and is incredibly organic; it felt like it is timeless," and a nearby window "feels like it is from another time, from its own time." The research and the conversation with the other participants revealed that the slopes are likely 10,000 years old, just like the arrival of the first human to the area, the oak is probably around 60, and when we say 'yellow forever', we relate to flowers found in 200-year-old abandoned cottages. The accompanying research and the conversation among the participants

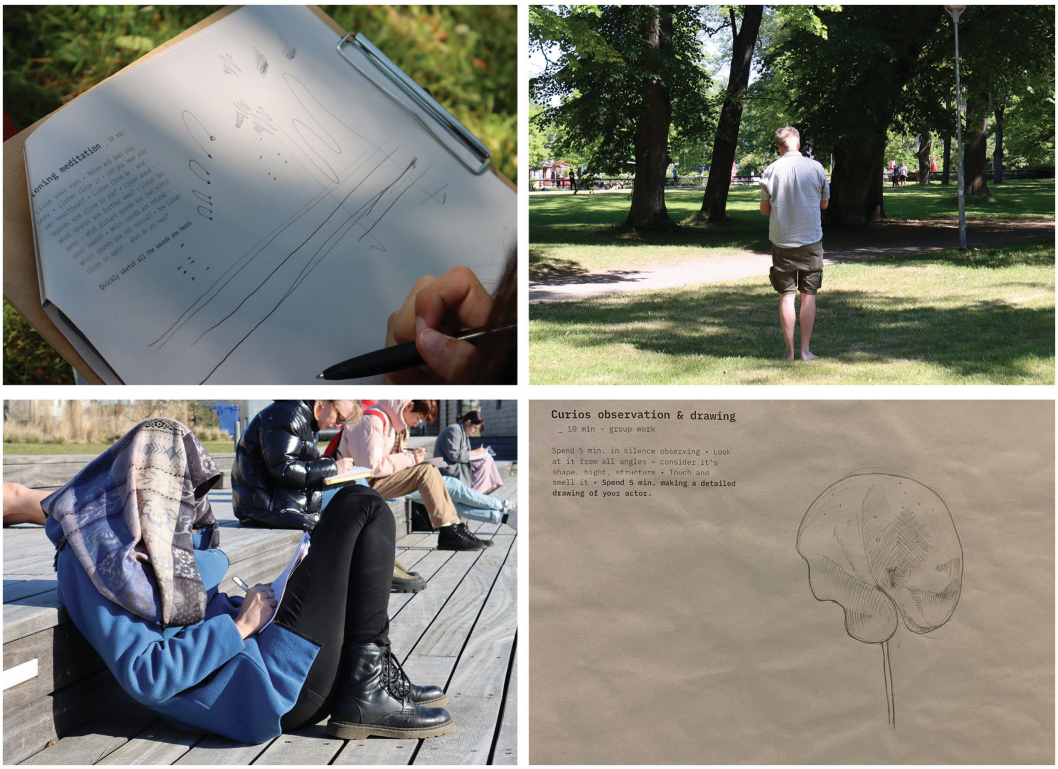

FIGURE 9
Participants adjusted to the environment and noticed details by slowing down and sitting quietly to draw visual, auditory, and sensual impressions.

allowed us to move from generalisation and guessing to more detailed and informed work.

4.4 Understanding the 'far lense' through the 'near lense'

When interacting with more-than-human lifetimes extending beyond human timescales, like those of trees and lichen, participants face the challenge of thinking into the deep past and the far future. To some extent, the visual mapping exercise helped participants overcome this tendency by identifying aspects of the individual actors by looking through the near lens and articulating how they indicate broad ecological changes likely to create a long-term impact assigned to the far lens. Thus, the near lens acted as a portal to a more extended period, and the visualization process helped to imagine the deep past and far future in detail and make it more concrete. In a few cases, participants got to think about deep time and how ecological changes unfold through interacting with the 'near lens' of individual actors. For example, following a depiction of a Cocksfoot grass, a participant expressed her thoughts about long time horizons, saying: "You cannot build over nature; time vaporizes everything. Nature will recover. If there is a crack, something will grow; if you leave an abandoned space for 20 years, nature takes over."

Another discussion emerged about Lichens growing next to glaciers. Lichens only grow on dry land, so their presence next to glaciers indicates glaciers retreat due to climate change. Observing the Cocksfoot grass placed on the canvas next to the Lichens, participants figured that another indication of climate change could be finding species typical to southern Europe, like the grass, in Scandinavia. In both cases, the near lens related to the actor indicates the far lens of ecological change. Another participant who depicted a Juniper shrubbery's pace reflected on how thinking through different scales leads to different realizations, saying that you can see how a plant reacts to a specific environment when looking at the details. Still, from a broader perspective, you interpret those changes in relation to bigger causes.

4.5 Comprehending times' relationality

The visual mapping allowed participants to understand the relational aspects of time, defined by (Tsing, 2015, p.34) as "interwoven rhythms." A sketching of a Juniper's shrubbery pace (Figure 10) led a participant to think of how it is affected by the external environment. He then realized that the plant's temporal perception is "influenced by all the time perceptions of other animals and humans that are imposing to it, like plastic bottles we drop or animals and humans seeking shelter."

Watching geese made another participant think in terms of music. She observed how various rhythms of different species come together (Figure 10), creating a composition: "The cycle of the migration can be merged with other cycles of other species, and in that way, you create a polyrhythmic pattern. It is like in music when you have several rhythms coming at the same time… it is a polyphony of multiple rhythms at the same time," she said. A participant who got engaged with seagulls mentioned her lack of ability to distinguish their

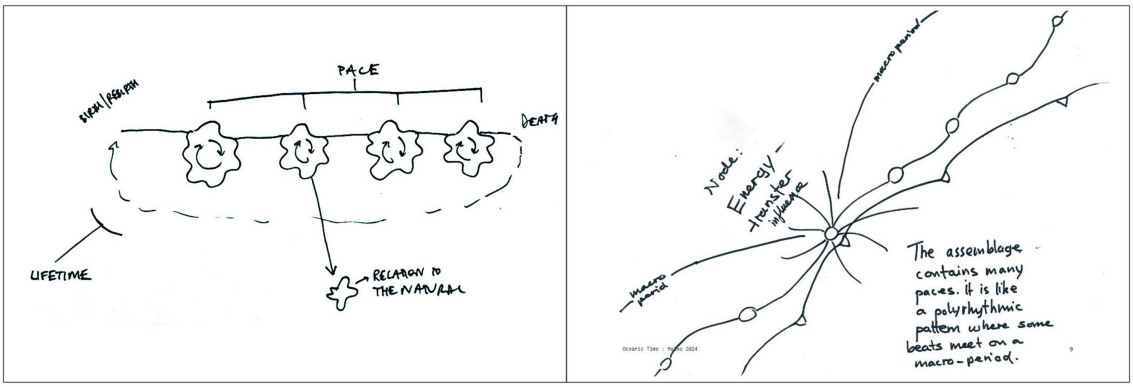

FIGURE 10
Left to right: depicting the pace of a Juniper shrubbery and geese.

FIGURE 11
Depicts two Weeping Willow trees taking the shape of a ball game with two courts.

time from other actors, as they were constantly involved "with the sea, fishermen, fish boats, and people," while a participant that observed reed expressed a similar realization, saying: "I learned there is a lot of interconnectedness between humans, reed, and species underground." She related to it as "a collective assemblage of different actors" and mentioned how the reed is dependent on cows to eat it, and humans to cut it down in autumn.

Four participants depicted a temporality of two Weeping Willow trees (Figure 11). The depiction relates to the different growing conditions of two trees, one growing in a central park area, watered and cultivated by humans. The other grew spontaneously from a crack in the pavement in a neglected spot. They chose to represent the two trees through a metaphorical ball game with two courts, where the tree is represented by a ball and the environment is represented by the court. While one environment is depicted as a smooth rail allowing fast and easy growth, the other is full of obstacles limiting it. The ball's pace results from the relationships between the trees and their environment. Similarly to Latour's (1997) description of different train rides and how they are a result of interactions and relationships, "the difference between our two voyagers comes from the number of others one has to take into account, and from the nature of those others" (p. 176). One of the participants reflected on how the pace is an outcome of the relationship of the trees with their environment: "These are trees in a garden controlled by humans, so we chose to depict it linearly. It would have looked different if it had been in a forest," she said.

4.6 Unfolding time

The visual mapping supported participants in unfolding the notion of time, becoming aware of its richness, plurality and multiplicity. One participant referred to the work of Haraway (2016), saying: "You get to understand there is so much accumulating, so it is like personhood or timehood. Haraway talks about 'thick presence', but there is also some richness when looking back; there is richness in time. Then you need more vocabulary, various terms to discuss and describe it, and various ways of drawing it to see the nuances of this richness." In another group, a participant reflected: "Not every temporality is similar. Just because we call it temporality does not mean it falls under the same category… What becomes clear to me is that when we talk about time, we mean very many different things." In a third group, a participant said: "The conversation [mediated by visual mapping] helped me externalise my thoughts as I feel time is abstract and sometimes hard to put in words. It affected my thinking as it opened up to new perspectives while discussing."

FIGURE 12
Left to right and clockwise: depictions of river slopes combining different life durations and evidence from various geological eras, Black Elder tree and its two trunks, Creeping Buttercup flower, lichen and a sketch of a Lichen's timeline.

4.7 Considering multiple timespans simultaneously

Thinking through the perspectives of more-than-human actors allowed the participants to consider multiple timespans assigned to the actors. For example, one of the participants interacted with a Black Alder tree. When presenting her work to the group, she related to the presence of what she perceived as a 'young tree', assuming it is around 20 years old, and to an 'old tree', probably around 60. To evaluate their age, she compared the trees to ancient trees she knew. She then imagined a potential future where the trees' pollinating system would help recreate life on Earth (Figure 12). Thus, interacting with a single actor allowed the participant to consider several timespans, including the different durations in the past (age) and the far future.

Other participants who interacted with the river slopes mentioned that they are an accumulation of multiple timespans, including the 10,000-year-old landscape, the plants and the different organisms, all layered and entangled, as expressed in Figure 12. While interacting with a Lichen, another group of participants drew its timeline by placing rocks representing deep time on one side and trees, human objects, air pollution and death on the other (Figure 12). The 5,000-year-old Lichen was spreading between the two poles to mark the long span of its lifetime, as opposed to the relatively new phenomenon of air pollution driven by human actions that can lead to death. By creating this representation, participants contextualised the Lichens' temporal existence to deep time rather than human life. The coming together of different actors assigned to different timespans in the visual mapping made participants reflect on how they are entangled. A participant who interacted with a Creeping Buttercup flower related it to the Lichen: "If people do not move the flowers, they can last 10 years. When you said that a Lichen lives 5,000 years, it was shocking to me, such a different relation to time in the same space!" (Figure 12). Participants in another workshop suggested using the concept of 'shared time' to describe the coming together of different temporal scales.

5 Discussion

"These are the times we must think," writes Dona Haraway (2016), referring to our global urgency. This paper responds to Haraway's (2016) call by suggesting visual mapping can help understand more-than-human temporalities in participatory design by thinking through them. The term 'thinking through' indicates a reflective practice aiming for a thorough and careful understanding, future- and possibility-oriented. It differs from other ways of thinking, such as 'thinking about', which indicates a distance or a gap between the thinker and the subject of her thought, or 'thinking with', which could refer to an instrumental approach where the thinker uses one idea to develop another. Unlike other forms of thinking, it emphasizes engaging with directionality, materiality and pace.

5.1 Directionality

The word 'through' proposes moving in the space "from one end or side of something to the other" (Cambridge Dictionary, 2024). As such, 'thinking through' suggests a journey, a process of navigation, where the thinker moves around and sees things from different points of view. The idea of a crossing path resonates with the work of Hayes et al. (2021), who described the multiple temporalities in participatory design through the metaphor of co-responding lines and Edwards and Pettersen (2023, p. 9), who underlined the need for envisioning different durations in urban design processes, which they refer to as "visions of different lengths." Unlike the linear perception implicit in these metaphors, in our work, the path of thinking does not take the form of a paved highway but a branching of multiple side roads of emerging curiosities, ideas and questions about time. In Tsing's (2015) terminology, this is a knotting together of different stories rather than a single one, creating 'interwoven rhythms'. Our view of these journeys is of an accumulated experience, a kaleidoscope. In our experiments, participants could see time and temporality in their multifaceted dimensions. They navigated between more-than-human time as it is observed by humans and imagined the temporal experience of more-than-humans. They thought about time through various shapes; they managed to look deep into the past and far into the future; they explored different scales and unfolded the thickness of what time is and could be in the present. Some participants related to the more-than-human actors they interacted with as voyagers. Several participants related to the interconnectedness of temporalities, and some associated them with musical compositions creating "polyrhythmic patterns." These rich journeys allow participants to look into different cases, develop multi-levelled interactions, bring ideas together, question meanings, form questions, increase sensitivity, suggest new vocabulary, and embroider stories. It allowed them to reveal time multiplicity realizing that "when we talk about time, we mean many different things." From this angle, our work contributes to developing the temporal discourse in participatory design (Saad-Sulonen et al., 2018; Rapp, 2022; Søndergaard et al., 2023) and emerging more-than-human approaches in participatory design (Akama et al., 2020; Smitheram and Joseph, 2020; Wakkary, 2021; Laurien et al., 2022; Romani et al., 2022), and their intersection as more-than-human temporalities (Mareggi, 2013) by suggesting how we can start accessing the idea of more-than-human time with its nuances and richness. It is a methodological suggestion of "appreciating polyphony" and "listening both to the separate melody lines and their coming together in unexpected moments of harmony or dissonance. In just this way, to appreciate the assemblage, one must attend to its separate ways of being at the same time as watching how they come together in sporadic but consequential co-ordinations" (Tsing, 2015, p. 158). The methodology we describe in this paper helps participants to think through different aspects of time and to flesh out times' multiplicity. The rich temporal vocabulary we gathered here can assist designers in choosing an angle to explore more-than-human time. This work is a concrete proposal for addressing complexity in design projects by considering multiple stakeholders beyond humans.

5.2 Materiality

The word 'through' associated with the thinking process suggests a traverse motion, where ideas move and develop in a space where materiality serves as a medium. Similar to the Lily's body growing through the water while consuming its material qualities, thinking occurs through the physical encounter with the materiality of the environment: the water, the soil, the grass and the wind, as well as the materiality of objects used in the visual mapping activity such as paper, markers, organic materials and wooden bricks. When participants think 'through time' rather than 'about time', time itself becomes materialized as "the mind converts into physical dimensions" (Fisher, 2023, p. 124). This was evident when participants described time as 'dense', 'thick' and 'abstract', and in materiality-based ideas like "accumulated time" and "extracting from time." "It matters what thoughts think thoughts," writes Haraway (2016, p. 35), acknowledging ideas do not appear from an abstract transcendental source but evolve from a specific substrate, allowing them to grow as such. In our experiments, this substrate was made out of tangible and materialized interactions, developing the interpretation of what more-than-human temporalities could be. The methodology we describe in this paper can support designers in making time tangible, thus allowing them to approach this transparent and illusive concept and consider it in the design process. By approaching 'visual mapping' as thinking through the making process, we expanded Latour (1986) notion of the map as a communication device to carry a dual character. In our work, the materiality is connected with a situated, temporal and process-oriented approach, where the visual map becomes a boundary object (Harvey, 2024), a medium through which the participants can think. Like the old Chinese person who drew a map in the sand, our visual maps are not meant to last or function outside the encounter; therefore, they allow a fluid and momentary materiality. However, when we ask participants to visualize their individual experiences or impressions with the rest of the group and document the situated and temporary artefacts to share with a wider audience, the visual mapping becomes a communication device. Thus, another contribution of this paper is consolidating the term 'participatory visual mapping' (Buur et al., 2013; Gaudion et al., 2015; Vrancken, 2018), suggesting that when the terms 'participatory' and 'visual mapping' are combined, they give rise to a double mode of practice, which functions as a device to facilitate an embodied and complex thinking process and as an output. In the context of more-than-human temporality, it facilitates the understanding of time due to otherness and relationships (Latour, 1997) and serves as an output to represent and share this thinking with others.

5.3 Pace

'Thinking through' conveys a deliberately slower and detail-oriented way of thinking. Farías (2017, p. 39) wrote: "What quickness does is invoke a certain type of knowledge, one assumed to be straightforward, based on best practices and on mastering whatever needs to be done." Visual mapping allowed new knowledge to emerge by creating an 'attention attunement' (Hayes et al., 2021) through observing, sketching, listening, and commenting on each other's work. This particular element is expressed in the notion of 'workshop time' as a multilayered interaction of different temporal dimensions. Pschetz and Bastian (2018) recognized that dominant narratives of time have limited design possibilities because they simplify temporality into dichotomies, such as fast and slow. Indeed, 'workshop time' is often perceived as a solid term equal to its duration. This paper unfolds workshop time into multiple temporalities, including workshop duration, the online dimension and the participants' pace. Leveraging these categories can help designers supplement the limited workshop duration with technological dimension and apply a different pace. Visual mapping created the opportunity to slow down and counter the fast-paced work that often characterizes design.

6 Limitation and future research

This research intends to observe and analyze the impact of visual mapping as a methodological approach to thinking through temporality. Evaluating the effectiveness of the proposed methodology is difficult due to several reasons. First, temporality is abstract and non-tangible in nature and, therefore, difficult to grasp and describe in objective terms. So is the act of thinking, which is mostly an internal process. The evidence of the thinking process is, to a great extent, the discussion among the workshop participants and the visual output they create. However, we recognize that the quality of the discussion and the depth of the results are not only a consequence of the methodology itself but also depend on other aspects, such as the facilitation process and the participants' skills, visual literacy and previous knowledge. Therefore, more systematic research is needed to investigate the interplay of all these aspects.

Based on our experience in the workshops described in this paper, we envision several possible directions for future research. The first relates to broadening participation. The participants in this research came from Europe and were educated to a university degree. We believe exploring the topic with more participants from other cultural backgrounds and life stories will be valuable. As humans, we tend to project our perception and situated knowledge on more-than-humans; therefore, it may be the case that interaction with people from other backgrounds will result differently. Another direction for further research will be the aspect of materiality and how it informs our idea of time. In our program, participants developed their thoughts through more than human temporalities using different materials to create visualizations. Our impression was that the specific material quality affected the ideas that emerged. For example, materials of a certain nature, like markers, nudged participants to think about time in a linear way, while materials like wooden balls led them to think about time as movement. Future research could examine the impact of materiality on our understanding of time. A third direction of future research should integrate these results into a design process that includes complex environmental challenges in projects of multiple stakeholders to address the premise of this work, which is to understand more-than-human perspectives through a temporal lens better.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Written informed consent was obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

HZ: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing. LS: Conceptualization, Supervision, Writing – review & editing. AG: Supervision, Writing – review & editing. NM: Supervision, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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