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A Storytelling Methodology to Facilitate User-Centered Co-Ideation between Scientists and Designers

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Abstract: Successful implementation of sustainable innovation requires strong collaborative ecosystems. In particular, collaboration between scientific and people-centered expertise (e.g., designers) is essential to bring technical innovation through contextualized, meaningful and attractive experiences. However, in practice, these types of expertise are siloed and struggle to communicate and think together. We present a creative design method based on participatory story building to support collaborative user-centered ideation between technology scientists and designers. The core of the method is a new story creation model, the three-tension framework, that facilitates the exploration of users' experiences and needs during ideation. To evaluate the method's effectiveness, we conducted open-ended interviews with participants. We found that the method facilitates the expression of different perspectives and outside-the-box creative thinking. An originality and strength of our method is that it favors the discovery of new issues and pain points—rather than only solutions. This, combined with idea enrichment by multidisciplinary expertise, contributes to generating ideas in a broader range of application areas than usual. Our results indicate that participatory storytelling has the potential to facilitate multidisciplinary collaboration and to bring user-centered thinking to non-design stakeholders in order to envision user needs in future scenarios and new ecosystems.

Keywords: co-creation; multidisciplinary; storytelling; sustainable user-centered innovation

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1. Introduction

Addressing the current global environmental and social challenges requires a holistic approach whereby collaboration and perspective sharing are essential across large ecosystems of stakeholders [1–3]. Organizations need to prioritize collaborative creation and the implementation of sustainability-advancing knowledge, concepts, and transformations [4,5]. In particular, integration of the technology and user-centered practices is key to sustainable innovation [2,6]. Scientific or technological discoveries are often at the root of innovation by forming a new problem or opportunity and have an important role to play in creating disruption to accelerate change [7,8]. However, as for radical innovation, the implementation of new technologies in the context of sustainable products and solutions is substantially hindered by initial low attractiveness and social desirability, and because it requires new consumer practices [3,4,9]. Combining technological innovation with user-centered methods is essential to ensure that people's needs are central in product or solution development, to envision the impact of the technology in practice, and to create consumer interest and engagement through desirable experiences [10,11]. We can find examples of such a desired impact in circular solutions that are attractive to consumers [12] or healthcare services that are accessible and relevant in their context [5]. The creation of viable and compelling experiences from a technological disruption, or the creation of

radically new experiences or contexts of use from existing technology, has the potential to lead to radical and sustainable innovation [13–15].

Technology explorations and new knowledge are often brought by scientists in a fundamental area (formal, natural, or social science) or in interdisciplinary and applied sciences (such as engineering, development, and medicine), while user-centered thinking is at the core of the designers' approach [16]. Several studies can be found on the collaboration dynamics between technologists or scientists and designers [10,17–21] (in the following, we regroup under the term "scientist" professional or graduating researchers and engineers in academic and applied R&D environments working on fundamental science and technology development). While user-oriented design approaches have the potential to drive interdisciplinary creative ideation, where the "voice of the customer" and the technical aspects are combined [13,22], in practice, there are still multiple cultural and structural barriers to effective collaboration between scientists and designers. These barriers contribute to maintaining the schism between the sciences and humanities in intellectual western society; Snow et al. [23] qualify this as a major handicap to solving the world's problems.

The first major barrier is created by the differences in mindsets, thinking models, and communication styles between science and design [10,19,24–27]. Scientists seek "cognition" and produce "new knowledge", while designers look for "designability" and create "new experiences" by envisioning and developing products or solutions that meet people's needs [16]. Scientists are mostly interested in "what exists and is observable" and the "truth of their propositions", contrasting designers, who are concerned with "what will exist and is unobservable" and the "plausibility and compellingness of their proposals" [25]. The differences in communication style are also evidenced, with scientists' preferring abstract mathematical explanations and designers having a predilection for concrete images, figurative models, and prototypes [19,24,25]. We acknowledge that the professions sometimes overlap—for example, looking at design engineers with a focus on technology or at scientists in the field of cognition or social sciences, who use methods similar to design research.

Next, there are structural barriers linked to the siloing of professions: an unclear definition of the designer's role in multidisciplinary projects, poor understanding and recognition of the designer's contribution by the scientific collaborators [18,19], late involvement of the designer in the project [24,26,28], and low involvement of scientists and technologists in the design process [28,29].

We present a design method developed to support collaborative ideation among scientists and designers and to bridge the communication and culture gaps. This research was conducted in the context of a leading multinational corporation with the aim of streamlining and speeding up the process of bringing to the market sustainable healthcare innovation carried by meaningful and/or new user experiences. In this study, scientists were researchers working in an R&D department with a background in engineering, physics, electronics, optics, neuroscience, and cognitive sciences; designers were design researchers, design strategists, and product and UX designers working in another department of the same company. We used the method in the early, explorative stage of innovation—the "fuzzy front end"—where creative ideas are generated that contribute to successful innovation [30,31]. As Lord Sainsbury highlighted, "the use of design helps scientists to develop commercial applications for their work while it is still at a research stage or at the outset of technology" [32]. The method is based on participatory story building [33,34], a creative user-centered design method rarely used in multidisciplinary settings, with the potential to provide a common understanding and vocabulary between different disciplines [35–38]. We built on known storytelling tools and adapted these methods, introducing a new framework applicable in a multidisciplinary setting, which encourages idea generation through imagining and detailing user experiences and problems. In this study, we set out to explore the usefulness of the method in terms of short-term outcomes (collaborative ideation dynamics and the resulting ideas) and long-term outcomes (relationship build-

ing, change in perspective, mindset, or way of working of the participants, as well as the method's uptake).

1.1. Compartmentalization of Scientists' and Designers' Expertise

Co-creation is defined as a form of collaborative innovation where ideas are shared and improved together with experts and/or stakeholders. Co-creation in a multidisciplinary team combining scientific and design disciplines is necessary to generate new ideas that have both a technical and a human-centered element to deliver a new experience. Such an approach has been referred to as "radical innovation of UX", "meaning-driven innovation", "experience-driven innovation", "radical innovation of meanings", or "task-pioneering innovation" [7,13,39,40]. However, the literature on these processes compartmentalizes the contribution of the scientists and designers: the scientists bring technology insights, upon which attractive or new UX are developed by designers.

The most extensive studies on the topic of collaboration between scientists and designers [10,18,21] explored how designers might support scientific research and they identified barriers and opportunities for this collaboration. A clear result is that communication issues can be partly overcome by maintaining frequent contact in the form of brainstorming sessions, meetings, and workshops [10] or through the creation of physical artefacts [21]. Summarizing these studies, the possible contributions of the designers to scientific research are:

- Finding applications for new technologies and scientific research outcomes by ideating and visualizing use scenarios;
- Unlocking scientists' tacit or implicit knowledge (knowledge that is difficult to articulate or present tangibly [41]), challenging their perceptions, and stimulating new ideas or research direction through design artefacts;
- Creating technology prototypes for testing and experimentation;
- Assisting with the communication and dissemination of research through the visualization of scientific ideas.

This collaboration is generally structured around complementary tasks and design is still perceived as a support function in scientific research environments [10,19,26]. In contrast, when design thinking is used without involving the technology counterparts—for example, the development team—there is reluctance when integrating the outcomes, and the user insights can be perceived as being unspecific because they are not directly translated into technical requirements [28]. It is unclear whether conducting these tasks collaboratively would lead to better results.

There is a need for the improved integration of both professions, and a re-evaluation of the designer's role in the innovation process, but also of the scientist's role. There is a common perception of the designer as the inspiration carrier, the creative challenger [42], and an unspoken bias that scientists are less creative. However, scientists also have a strong creative dimension, residing in a pursuit of an inner vision, an intuition, an attractive challenge that is not always rooted in marketing reality [13]. Even though there is generally a stronger analytical component for scientists and a stronger intuitive component for designers [19], the high level of creativity in both professions may be a stronger common denominator than generally thought.

A successful collaboration between the disciplines requires an atmosphere conducive to a two-directional openness to each other's mindset and way of working and understanding of each other's ideology [10]. Only then can there be tacit knowledge transfer between scientists and designers that is essential to develop new product ideas [43].

1.2. Storytelling as a Design Method to Facilitate Co-Creation between Scientists and Designers

User-oriented design or design thinking approaches have grown tremendously as ways to drive interdisciplinary creative ideation [43–45], to place the user perspective at the center of the creative process in the early stages of innovation [13,22], to boost innovativeness [46], and to reduce cognitive bias [47]. However, co-creation and creativity are still critical issues in the innovation process [43,48], especially in large organizations [49–51].

Too little is empirically understood about how to foster collaborative innovation and the impact and underlying dynamics of design thinking [22,47,52].

While the view in academia is that design methods are instrumental to the success of product development in companies, their application and uptake is limited in organizational contexts. This is attributed to difficulties fitting the methods within existing structures and cultures [22], a problem accentuated by the frequent development of the methods in an academic context and the lack of evidence or empirical data that prove their effectiveness and efficiency [53]. Furthermore, it is suggested that working with design thinking requires a specific type of mindset [28]: in particular, design thinking may be challenging for scientists who typically take a linear approach to problem solving [27]. Design thinking effectiveness has mostly been studied in design environments, and there is much to gain by applying these learnings to a broader multidisciplinary community.

Only a few studies have been conducted on design methods applied together with scientists. Most of them are in an educational context with the aim of modifying the mindset and approach of technology students, rather than for concept or idea generation [54,55]. We only found one paper describing a concrete application of design methods in a multidisciplinary team of experts including technologists, with the goal of creating user-centered innovation [35]. They use story creation to facilitate multidisciplinary collaboration. They provide interesting examples of the application of stories in a product design process together with technologists and developers—namely, to convey customer feedback, to create use scenarios for a new product, and to imagine potential uses for future products. The paper does not provide empirical data on the dynamics of the collaboration or on the method's effectiveness, but the outcomes of the described examples suggest interesting benefits for the storytelling method as a multidisciplinary collaboration tool. It describes how, in real time, story creation enables multidisciplinary teams to incorporate their various and unique perspectives, facilitates idea exchange and enrichment, and favors creative and open-minded ideation around the user perspective.

The potential of storytelling as a design tool that resonates with scientists was confirmed in an interesting experiment by [36]. They used a scenario-based design approach with engineering students to simulate rare, unusual, hardly observable situations. They imagined how the user performs tasks in future prospective scenarios to reveal new contextual information, new meanings of the product, and new interpretations of existing technologies that ultimately can be translated to new opportunities for innovation. The approach was found to overcome fixation effects and promote divergent thinking. This study was conducted with a uniform cohort of students, and the authors recognized that empirical validation with experienced designers and in a multidisciplinary environment is needed.

These studies indicate that storytelling tools can facilitate co-ideation among different disciplines. Storytelling is a well-known creative tool in design practice [33,34,37,56]. Story and scenario creation are effective in using imagination to investigate and envision new users' behaviors, emotions, and contexts of use [34,57]. In essence, they provide insights into the user's experience and needs, either actual/real or future/imaginary ones. The tools include personas, scenarios, creative writing, storyboarding, customer journey maps, bodystorming, and acting. Storytelling can be used in the research phase to gather, structure, and share user insights; in the concept creation phase to imagine, map out, and communicate experiences of a product or service [56]; and in the early testing phase of solutions with story prototypes to uncover latent constraints and desirables [57].

Storytelling has the potential to bring user-centered and divergent thinking to scientists, who may tend to focus on the technical aspects and to have an analytical mindset [35,36]. Storytelling unlocks imagination for the storyteller and the audience; it helps to spark new ideas or perspectives [37]. Stories connect to people's individual memory, enabling them to tap into personal experiences and emotions for story building and story interpretation, again stepping away from a rational analysis [35]. Furthermore, stories are a universal means of communicating that brings empathy for users because they make concrete how a technology can be used in context and how a user would react to it [37,58].

Despite the broad use of story and scenario creation in the design community, these design tools have rarely been applied in multidisciplinary settings, and there is a lack of studies regarding how different experts can co-create a story and the effect of such a process on the generated ideas or concepts [59] and on the participants' mindset. As a participatory tool, it is known that storytelling transcends the cultural divides of multidisciplinary teams [35] and provides a common understanding and vocabulary [37,38] while putting the user needs in a central position [34]. Co-storytelling has been used as a participatory design technique to stimulate in-depth user feedback on early concepts or ideas for future applications [60,61]. In multidisciplinary organizational contexts, the role of storytelling is often confined to its communication, learning, and engagement functions [62–64]. Interestingly, though, stories of innovation have been positioned as a "boundary object", facilitating a shared understanding of innovation, and the coordination of actions [65].

1.3. Positioning of This Research

There is a lack of understanding on how scientific or technical and design expertise can be integrated in a creative process, and how to overcome the collaboration barriers and the deficient perception of the different roles. Design thinking methods, and especially storytelling, have the potential to facilitate this collaboration but have been little studied in multidisciplinary settings with technologists or scientists and particularly seldom in professional environments.

The method described in this paper aims at facilitating *co-ideation*, the most integrated form of co-creation, where scientists and designers ideate *together* on new meanings, new contexts of use, new experiences or interactions for a technology. We consider our use of stories as a boundary object between disciplines for co-ideation (see Figure 1), a bridge between the different expertise, creating a common language between designers and scientists. This is a similar approach to Ruckstuhl et al. [21], who use physical artefacts as a boundary object between the two disciplines in the context of material and process innovation—in our approach, the stories can be seen as experiential artefacts for user-centered innovation.

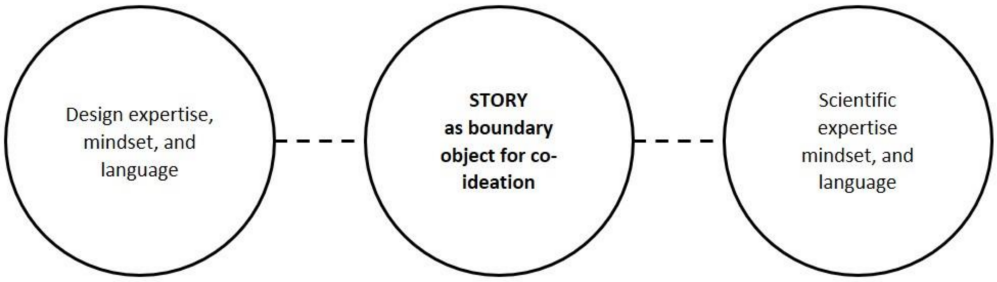

Figure 1. Story as a boundary object for co-ideation between designers and scientists.

In our research, we are interested in understanding the role that stories can play in the dynamics of such a co-ideation. We saw above that designers can support scientific research by finding new technology applications through the creation of user-centered scenarios. This contribution is clearly in line with our purpose to ideate on meaning-driven innovation. We want to understand if creating scenarios *together* with the scientists—rather than by the designers alone—helps to envision richer experiences thanks to the technology embodiments. We also saw above that a possible contribution of designers to scientific research is to unlock tacit or implicit knowledge and stimulate new ideas for scientists: we hypothesize that the benefits may be symmetrical, i.e., if designers are inspired by scientists, for example, through a new view on technical feasibility and future possibilities. All these effects can potentially influence the ideation dynamics, the resulting quality and number of ideas, and, in the long term, the participants' mindset, way of working, and perception of the other discipline.

Our research was initiated from a company's need, which was to reinforce the user perspective in technology-driven sustainable healthcare innovation. We used participatory storytelling to facilitate multidisciplinary ideation workshops, based on the indication in the literature that this method supports communication and openness to different perceptions and mindsets. By applying and optimizing our method within projects in alignment with the company strategy, processes, and culture, we can validate and enrich these initial findings and position the method and its outcome in the commercial innovation reality with experienced professionals.

2. Theoretical Background and Fundaments of Our Storytelling Method for Co-Ideation and Three-Tension Framework

Our developed storytelling method is a creative design method targeted at idea generation—prior to concept development. In five years, we have developed and improved the method by applying it in ideation workshops conducted for an innovative multinational company. Reporting on the method development or providing a toolkit is beyond the scope of this paper; in this section, we present the key elements for its implementation.

Our method uses elements from known story building and storytelling theory and tools [33,57]. Scenarios and stories are often used interchangeably in a design context, and both relate to a sequence of actions carried out by the user going through a design experience. A distinction can be made in the sense that stories include detailed descriptions of the people involved in a task, their motivations, values, or goals, while, in contrast, scenarios lack the plot development and drama integral to a compelling story [35]. Our method uses stories in this latter sense because they can capture a large number of relevant insights specific to both disciplines, create relationships between these insights, and store them in a coherent framework. The stories are positioned as a tool to ideate, not as an end result; it is not important to have well-told stories [57].

It is essential to include in the stories complexity in the form of plot twists, backstories, complicating subplots, and external factors that can distract the user and disrupt the experience, as in real user journeys [33]. This leads to unexpected constraints, conflicts, needs, and desires, hence sowing potentially new seeds for solutions. This can be compared to the study of extreme users who think and use solutions in extraordinary ways, which leads to novel insights and the design of sounder solutions [66,67]. Furthermore, including difficulties, constraints, and satisfactions promotes creative thinking by encouraging the participants not to consider existing products or services, but rather to find latent opportunities in the future [36].

However, building stories with sufficient depth and complexity is difficult in practice for most people, including designers. Often, design stories are very condensed; only the key dramatic details and moments central to the design being investigated are portrayed [57]. This is what we observed while developing the method, and it was even more critical with participants who had little or no experience with story building or user-centered design. It was essential to have an extremely clear process in the workshop, and to sequence the story building into exercises bringing a high level of granularity in the story description. To guide participants to describe personas and contexts holistically and deeply, we developed the three-tensions framework (Figure 2). In this framework, the design tensions represent the user need or problem similarly to the typical problem formulation in classical design approaches. The design tensions are documented from, e.g., design research. Our framework emphasizes the internal and contextual tensions that are a mix of real insights and imagination. The internal tensions relate to the inner world of the persona, i.e., their emotions, desires, hopes, fears, etc., and include references to their past. The external tensions describe how the character interacts with the world, be it spaces, devices, or other people. Building internal tensions helps participants to step into the persona's shoes and build empathy; building external tensions pushes them to visualize interactions. By combining these tensions in the story, unexpected clashes emerge, moving away from

the ideal journey and leading to the identification of unthought-of needs and problems, such as unpredictable behavior or resource misuse.

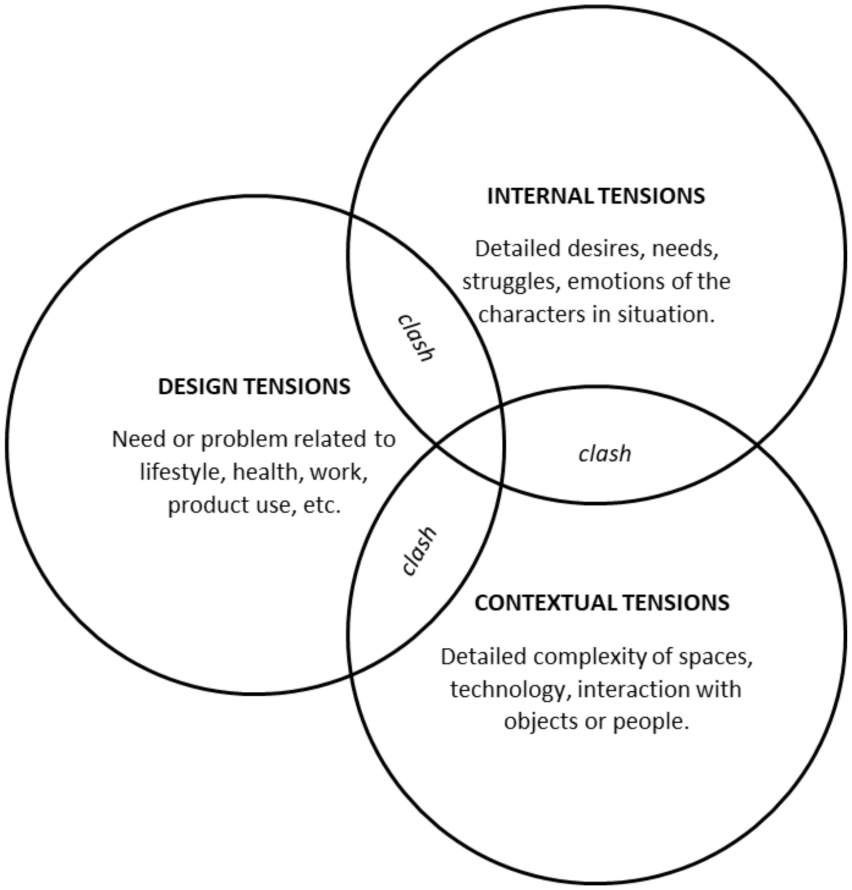

Figure 2. Three-tension framework: a guide for multi-tension story building and the emergence of unthought-of clashes.

This framework was used for persona creation, after which we used Freytag's story structure [68]—see Figure 3—as a guide for participants to make their persona progress through the series of clashes identified from the three-tension framework. The participants imagine how the journey of their personas unfolds, adding struggles and tensions along the way, describing how the characters react and what they feel for each step of the situation. To solve the problems arising in the story, solutions can be inserted. The participants detail the interaction between the user and the solutions, making new problems emerge. The ideation happens implicitly when the story is built using story arcs based on tensions that are the seeds for new inventions. The ideas are contained in the stories and are only extracted and filtered in a second phase of story sharing and analysis. By focusing on story building rather than ideation, participants can deviate from the classical linear problem/solution brainstorm approach.

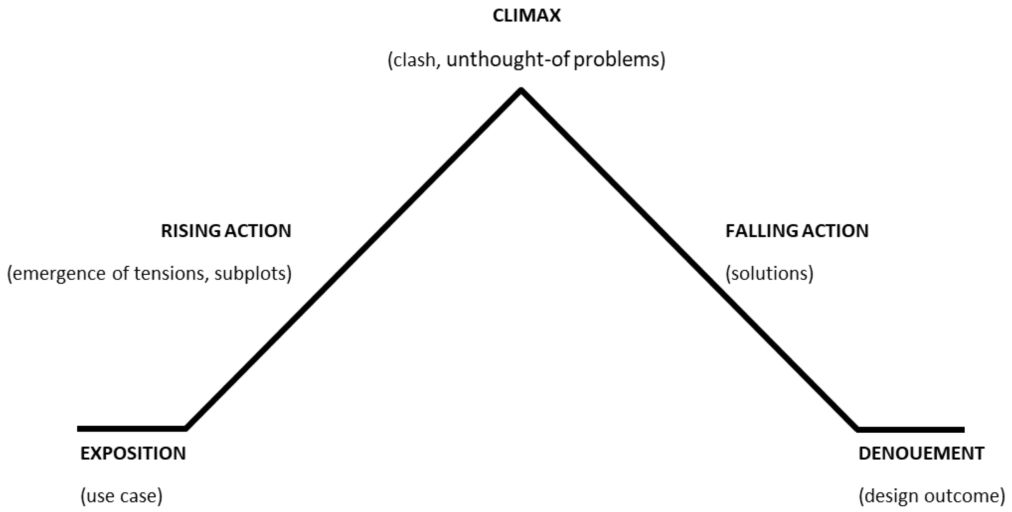

Figure 3. Freytag's story arc adapted to ideate on inventions.

3. Materials and Methods

We first describe the practical set-up of the workshops that we conducted, followed by the process of data collection through participants' interviews and data analysis.

3.1. Participatory Story Building Workshops

We evaluated the storytelling method using empirical data collected through interviews after applying the method to three multidisciplinary co-ideation workshops with different participants and topics. The method was mature at the time of this study as it had been optimized iteratively in more than ten previous workshops conducted in a similar context. The workshops all took place in a company environment with scientific and design professionals.

The goal of the workshops was to identify new ideas to deliver healthcare with better outcomes, a better experience for the users (patients or care professionals), greater accessibility to care, and/or a lower environmental impact. More specifically, the workshops were directed towards solving a health- or lifestyle-related user need using new technologies with a user interaction component, e.g., interactive data visualization, virtual or augmented reality, digital conversational agents, device adaptation to contextual awareness, etc. All the workshops were facilitated by the authors, who have a dual scientific and design background. The workshops' participants were scientists from different specialisms (engineering, physics, electronics, optics, neuroscience, cognitive science), designers (product and UX designers, strategic designers, design researchers), and a small number of other stakeholders (users, marketers, business leads) needed to provide insights relevant to ideation.

1. Scoping

The scope is defined as the combination of a technology direction established with the scientists regarding a technological innovation, and an unmet user or clinical need.

2. Preparation

Participants provide relevant inspirational content presented in the workshop, e.g.,

- data on user needs or problems (e.g., user interviews, user personas, experience flow, clinical insights, social and lifestyle trends);
- technology insights (e.g., technology basics, current or envisioned technology applications, technology trends);
- business and market insights (e.g., benchmarking and business landscape around technology or solutions for the unmet need).

3. Workshop

The workshop ideally takes place in a face-to-face context, takes 6 to 7 h, and involves 6 to 15 participants. The workshop can also be conducted online and is then split into several sessions. There are variations in the workshop process and tools, which are beyond the scope of this paper, but the basic structure is as follows:

- **Knowledge sharing:** specialists share their insights, and, if possible, real users describe their experience around the scoped need. Re-acting of the user experience is sometimes used to achieve a deeper understanding and empathic feel of the situation. This phase is plenary, and then the participants split into sub-teams of 3–4 people for the rest of the workshop.
- **Imaginary personas** are built by the participants using detailed templates that ask questions about the character's life, past, and expectations, based on the 3-tensions framework (Figure 2). The personas are a combination of real insights gathered from the knowledge sharing and imagination. If some aspects of the persona are too unrelatable for the participants (for example, if they are care professionals or users from different cultures), the personas can be partially worked out before the ideation by a team of designers, and a story is told around the multiple tensions of the personas to introduce them in the workshop.
- **The story arc** is built following a basic story arc structure (Figure 3) [68]. The story arc can be collectively sketched on a board, in some cases using pre-defined templates. The participants use real needs and problems of users gathered from the knowledge sharing and add imaginary struggles to build a story. They discuss how the personas feel and react for each problem in the journey. To solve the problems arising in the story, solutions may be inserted that use the technology. The participants detail the interaction between the user and the solutions, making new problems emerge. If the stories take place in contexts that are unrelatable for the participants (for example, specific to some professions or cultures), story pieces highlighting problems can also be worked out before the ideation and the participants use these to ideate on how the story unfolds.
- **Storytelling and enrichment:** each team shares plenarily their persona(s) and story to the other teams. This can be done by (a combination of) speech, body storming, acting out, mocking up, scripting, video recording, or writing a short story, depending on the use case and the participants' level of comfort with the technique. Some methods are more suited for certain use cases (e.g., scripting works well for conversational interfaces, body storming for gesture-based interaction). After the story is shared, the participants discuss the moments in the story that are unexpected, such as a surprising use of the technology, a surprising persona's behavior, an unthought-of need or problem.

4. Idea filtering

The problems and ideas from the workshop are listed, and the stories are read or watched and reflected on afterwards to extract more unexpected problems, solution ideas, and topics. The ideas, problems, and topics are listed and evaluated for novelty, technical feasibility, and relevance for the company businesses. The evaluation is done by scoring along these three parameters by a sub-group of the workshop participants who have knowledge on the state-of-the-art in the field and the company strategy in terms of business and patent portfolio. The ideas that are scored positively in the three categories are selected for further concept development or patent filings. The problems and topics that are novel and relevant are selected for further ideation.

3.2. Data Collection

The empirical data were collected through semi-structured interviews following pre-established, open-ended questions about the experience of the participant during the workshop, their opinions on the generated ideas, the effects of the method after the work-

shop on their perception of the other disciplines, their mindset, behavior, and way of working in projects. The full questionnaire can be found in Appendix A.

- The first workshop was held in August 2018 face-to-face and consisted of 9 participants: 4 designers (including 2 of the authors of this paper, who facilitated the workshop), 4 scientists, and 1 clinical specialist. Of these, we interviewed 2 designers and 2 scientists.
- The second workshop was held in July 2019 face-to-face with 14 participants: 6 designers (including 2 of the authors, who facilitated the workshop), 5 scientists, and 4 business and market stakeholders. Of these, we interviewed 3 designers, 3 scientists, 1 business lead, and 1 market lead.
- The third workshop was held in March 2021 fully digitally and consisted of 10 participants: 4 designers (including 1 of the authors, who facilitated the workshop), 5 scientists, and 1 clinical specialist. Of these, we interviewed 2 designers and 2 scientists.

A total of 16 interviews were held between March and April 2021, lasting between 30 and 45 min each. For the first workshop, the interviews were conducted almost 3 years after the workshop took place, almost 2 years for the second workshop and 3 weeks for the third one. We used this different time span to look at short-term and long-term effects, as assessed by the participants. The interviewees were selected on the basis of their involvement in idea evaluation and filtering after the workshops, so that they had an overview of the ideas and their characteristics. We estimated that 16 interviews were sufficient to derive solid conclusions as, during the interviews, we observed a convergence of the answers. This number is consistent with studies that report that 12 to 24 interviews are needed to reach meaning saturation (the point where a full and rich understanding of the topic is achieved) [69,70]. The interviews were conducted digitally through the communication tools Microsoft Teams (n = 15) and WhatsApp (n = 1). A digital audio recording was made with permission from the participants and the recordings were fully transcribed.

3.3. Data Analysis

The content of the transcripts was analyzed using thematic analysis [71]. We approached the analysis in an inductive manner, coding the transcripts from a bottom-up perspective. Two of the authors read through the first transcript together and identified potentially relevant themes, while staying close to the transcript, i.e., away from higher-level semantic interpretations of what was said during the interview. Quotes belonging to the relevant themes were then tagged in each of the transcripts by one of the authors. The other author then read through the coded transcript and, in case of disagreement, both authors discussed until consensus was reached. In a second round of analysis, the quotes from all interviews belonging to the same theme were combined, and the authors discussed emerging patterns for each theme (using minimal rewording of the actual quotes), as well as higher-level themes encompassing several of the lower-level themes, arriving at a three-layered semantic interpretation of the data.

4. Results

The results of the 16 interviews were initially coded into 19 emerging themes, grouped into five encompassing categories. The full results are available in Appendix A: it includes a table of the themes per category with the number of quotes of scientists and designers per theme (Table A1) and all the conclusions per theme with a selection of quotes (Table A2). We present here a summary of the most important conclusions and significant quotes for each of the five categories:

- Enabling multidisciplinary creative collaboration (seven themes);
- Promotion of user-centered thinking (three themes);
- Range and type of generated ideas (three themes);
- Relevance of the tool in innovation (four themes);
- Impact on mindset, perception, and way of working of participants (two themes).

4.1. Enabling Multidisciplinary Creative Collaboration

We identified seven themes (in bold) related to the impact of storytelling on multidisciplinary collaboration in ideation.

All of the 16 participants stated that, in ideation, it is beneficial to **bring different perspectives and disciplines together** (research, business, design) to set up a collaboration space where everyone can contribute their expertise and insights, and that the storytelling method facilitated this.

> "When you come together with designers, with people in business, with people from research, I think that is where, you know, that's where the Magic happens".
>
> (a scientist)

Respondents recognized the differences in the approaches and thinking styles of scientists and designers, as well as a stereotyped perception of designers amongst scientists, where designers are confined to a form-giving role and not always considered as partners to generate solutions. Half of the participants, both researchers and designers, mentioned that the storytelling method helped to bridge these differences in roles by enabling **inclusiveness with respect to expertise or perspective**. They indicated that each participant could easily translate their perspective through a story, and that there was no difference in emphasis on the input of one particular person or group of persons with a given expertise.

> "It's good to kind of mix them up a bit and, then again, because the way the method is scripted, you kind of empower everybody. Doesn't matter who contributes, it's not like a math problem where only the engineers are happy because they're consulted, and others feel left out".
>
> (a scientist)

> "I felt all ideas or train of thoughts were very well encouraged. So there was no judgement. And I think potentially the storytelling helped there, because we were like thinking about: oh yeah, a fictive character. Yeah. So it was not that there was one specific idea based on previous experience or an interview that may be invalid; everything was possible because it referred to a specific, fictive person".
>
> (a designer)

It was also suggested that storytelling broke down barriers for people to speak up because of the fictional nature of the character—everything was possible. All ideas or trains of thought were encouraged, and there was no judgement—in contrast with other types of ideations that are framed in reality, where ideas can more easily be invalidated. For example, participants were not limited in their thinking in terms of what is only technically possible, which allowed unexpected and outside-the-box ideas to arise and be combined with expertise, which in turn led to connections that would not otherwise have been made, resulting in a **collaborative creative mindset**.

> "I feel like otherwise you will easily get trapped in a more technological discussion, potentially also hindered by what is possible and what's not possible this far".
>
> (a designer)

> "What often happens and especially when you're so deep in the topic, [. . .] you create this one directional way of thinking [. . .] and then it's always good, once in a while, to have other people looking at that completely differently so that you know: OK, I have to open up again because I'm focusing too much again on the topic [. . .] I think it happens in any cocreation session. But I think what happened here is because of the storytelling".
>
> (a scientist)

> "We came up with crazy stuff. [. . .] as researchers can be, they can be very excited about a specific detail, and then when they put it into a story, it's actually quite an interesting concept or idea".
>
> (a designer)

Nine of the 16 interviewees acknowledged that storytelling is a common language that helped participants to **communicate** their ideas in an understandable way, so that everyone could grasp and also add to them.

> "The flow of the workshop was very natural, and it helped to align and to find common ground in thinking about these ideas".
>
> (a designer)

Several participants described storytelling as a **quick way to get people on board**, to put people in the right mood and in a creative mindset, unlike in typical ideation sessions, where this may take more time and effort. The low threshold was related to the familiarity of everyone with the basic principles of storytelling.

> "Normally you have a workshop and then people say OK start brainstorming. It's not a button!".
>
> (a scientist)

> "I'm bad at drawing and you know I would do it. But telling a story or coming up with a story is actually maybe a lower threshold for a lot of people, so [. . .] you have more people in the creative mindset".
>
> (a designer)

All but one participant perceived the workshops as fun, playful, relaxed, exciting, and felt that they had a **positive and energizing atmosphere**. They indicated that this motivated them to contribute. One scientist claimed to be overwhelmed at certain times during the workshop.

> "It makes people curious, [. . .] they started to have fun. I felt empowered, excited. [. . .] I was at a party!".
>
> (a scientist)

> "So for me these were quite exhausting days. You have to be really engaged and that engagement, yeah, it takes quite a quite a lot of energy if you want to be fully engaged. I'm also a fan of like this workshop event and you need it if you really want to get something done. I was happy to engage, engage with the team".
>
> (a scientist)

For scientists especially, storytelling was not something they did daily; it took them **out of their comfort zone**. This was indicated by one participant as, "encouraging new perspective taking".

> "I think it this famous thing of taking people out of their comfort zone. I think you can definitely achieve that with this approach. Because it takes them out of the technology bubble or the doctor bubble or whatever bubble they're in, it takes them out of that bubble and it forces them to try to take that other perspective, even if it's only for a few hours".
>
> (a designer)

4.2. Promotion of User-Centered Thinking

We identified three themes (in bold) related to the impact of storytelling on user-centered thinking in ideation.

All participants said that the method helps in **bringing a user perspective to the ideation**, in contrast to other more technology-focused ideations that they had experienced. By bringing the participants' ideas together with the perspective and context of the user,

it enabled them to discover whether ideas were relevant and practical or not. This was considered to be especially beneficial for the scientists by both groups, as they often forget to connect with the user and to consider the emotional benefits and other design aspects. The participating scientists said that they enjoyed being brought out of their technological sphere and that storytelling forced them to put themselves in the shoes of the persona and this made the emotion of the journey flow in a natural way. One designer indicated that designers also sometimes lack a user-centered focus and therefore benefit from the storytelling method.

> "It's a completely different angle than this technology push, this is something I think that we do too much in research, that we have a certain technology and then we're going to look: OK, where does it fit? Now we have a problem, and whatever technology or method can be applied there is all open, and I think that's my sort of takeaway message. [. . .] This is also, yeah, almost the most important thing if you want to create something for people; you first have to study the people that you're designing for, developing for".
>
> (a scientist)

> "Many designers initially are very much thinking about [. . .] cool stuff they can make, but not always useful ones. [. . .] It's more in the line of thinking 'because we can', not necessarily because it's going to help users".
>
> (a designer)

> "What I think it really brings is having to step out of the theoretical sphere and really look at something that gives you more information, more point of view from practice. So that's one, and the other is actually having to think about people. So really, the story is about a person and you have to use empathy; you have to project your point of view from the point of view of that person. So that's also something that's really strong in this methodology".
>
> (a designer)

The benefit of using **detailed personas** in the process was acknowledged by the majority. They indicated that the story brought the personas to life, that it forced them to consider how their ideas fitted into that specific individual's journey, what would be their real-life experience, issues, and relationships with other people. By "being in the skin" of a particular type of persona, participants stated that they understood them more deeply and could truly empathize.

> "Let's not understand them [the personas] as an object, but try to understand them from the inside out. Well, that's what storytelling does".
>
> (a designer)

Several interviewees compared **going through scenarios** to that of experiencing a real product. They stated that it forced them to think about the consequences of their ideas in real life, hence improving on the interaction, usability, attractiveness, and usefulness of a product for an audience.

> "You're forcing people to think what the consequences are of doing this. And yeah, you sort of might find out that the consequence doesn't work unless you do something. So, to me, that's always been the strongest part of the storytelling".
>
> (a scientist)

Another benefit mentioned was that participants could map their own experience of the topic into the story. This was indicated as being beneficial for user-centered ideation; however, a designer indicated that it is difficult to get people into the right mood for user-centered thinking, even when using the storytelling method, as people tend to stick to their own world views and own perspective rather than that of a future user.

4.3. Range and Type of Generated Ideas

We identified three themes (in bold) related to the impact of storytelling on the range and type of generated ideas.

Half of the interviewees, designers and scientists, stated that the **scope of ideas** was broader and more diverse than in "typical workshops", specifically in relation to connecting ideas to services and platforms outside the participants' area of expertise. By "typical workshop", participants referred to past workshops in which they had participated that used a broad range of known ideation techniques, such as TRIZ, mind mapping, sketching, simple "brain dumps", etc. Most of them also said that the storytelling workshops were very productive, and they generated **more ideas** than in other ideations. The other half did not mention the quantity or range of ideas.

> "It was a kind of a pressure cooker workshop, so I was impressed by the number of ideas we had in so little time".
>
> (a designer)

> "It's richer, it maybe gives you more avenues for coming up with ideas [. . .]. You start to see: oh yeah, well, this might connect with this and there's a whole story around it. So then you say: oh well, I can approach it from different angles".
>
> (a scientist)

Opinions varied with respect to the **quality of ideas**, with some interviewees finding the ideas more thought-through, and some finding them less complex and less concrete than with other ideation methods (without correlation of the answer to the discipline). Participants indicated that the idea quality and value benefited from the fact that participants enhanced each other's ideas through the storytelling process. They also indicated that by focusing on the situation and the experience, they went less deep into the technological complexity of ideas. Several scientists and designers observed that even if initially the quality of the raw ideas was heterogeneous, after selection, there were more high-quality and high-value ideas than in a typical brainstorm because of the large number of ideas generated.

> "I think that the quality was a bit less than I expected, but that was compensated by the amount".
>
> (a designer)

4.4. Relevance of the Tool in Innovation

We identified four themes (in bold) related to the relevance of storytelling as a tool in the innovation process.

All but one scientist regretted that, in product innovation, technology is too often developed without first identifying the users' problems, which may result in the low resonance of the product when launched on the market. They said that this could be prevented by promoting user-centered thinking and they identified storytelling as a good tool for exploring the user's problems at the start of the innovation journey.

> "I sometimes see that they created technology and after that, they start looking: OK, so what kind of problem can I solve? [. . .] Often you also see that ending up in the bin".
>
> (a scientist)

Other **uses for storytelling in the innovation process were mentioned**: as a tool to test early prototypes to gather preliminary user insights before testing with real users, for product roadmap building by ideating on future users' target groups and pain points, and for ecosystem innovation, where there are no clear existing business benefits or problems (an area where traditional methods would not suffice).

Several participants highlighted that through supporting collaboration with business stakeholders, storytelling helps to bring awareness about real user issues and how to solve them in order to align with the relevant **business opportunities** to be pursued.

> "There are many different stakeholders, and I think something like this would really help everybody get more awareness about what the problem is".
>
> (a scientist)

Storytelling was also said to help to optimize customer fit, validate marketing ideas, and identify new, maybe smaller, customer groups with high margins by taking an existing product out of context to unexpected application areas.

Both scientists and designers mentioned that stories are a good way to **communicate information and ideas**—for example, when following up or reporting on some concepts. It is easier to explain the idea and how it came to be in the context of a story and from the perspective of a person.

> "Sometimes [. . .] if you look at the specific idea like that, it's quite specific or random. But now, because he told the story, you can actually see how it came to be and what it's like in context".
>
> (a designer)

All but one scientist—but none of the designers—commented that storytelling forced participants to think about issues and conflicts through the story's need for drama. It made the user problems and the causes of those problems more visible and tangible and led to the **discovery of new issues and pain points**, which were the start of new solution ideas.

> "I still think that finding the problem is sort of the unique part of it. And I'm sure there are other ways to do the other things [finding solutions], but I don't think there are a lot of other ways to force the problems".
>
> (a scientist)

4.5. Impact on Mindset, Perception, and Way of Working of Participants

We identified two themes (in bold) related to the impact of storytelling on the mindset, perception, and way of working of participants.

Most participants indicated that the experience of the workshop **changed their way of working** in some manner. All but one of the scientists said that the workshop was a trigger for them to start integrating design tools such as personas into their brainstorm sessions. They mentioned that they learned about the value of the user-centered approach that they were, or planning to, starting ideations from problems instead of technology. Three designers mentioned that they started using personas and empathic story-building tools to incorporate experience considerations to a greater degree into their design process. A designer explained that many designers tend to leave out the emotional part, and that storytelling can fill this gap.

> "[before the storytelling workshop] my mindset was also, let's come up with something, let's invent, let's try design or create and then test. Now I first start, OK What do we need to show? What's the key problem that we need to solve? I think that really changed in my perception".
>
> (a scientist)

> "My mindset has I think a bit opened. You can see that there are other ways to collaborate and ideate [. . .] in general more than what we normally do in Design, right? We always have the same types of workshops. And I think this really shows that there is room for innovation here as well to come up with new ways of doing this".
>
> (a designer)

When asked whether their **perception of the other roles** had changed, participants indicated that they understood the role of the other expertise better and realized the

value of having different experts working together. Several indicated the intention to collaborate more often. Two of the designers explicitly stated that they were surprised that scientists were able to deal with the "fluffy" type of creative thinking, and one designer mentioned realizing that, for scientists, these kinds of workshops are fun and exciting. All the participants also noted that, other than this, their perception of the other's role did not change, as they all had collaborated with each other before.

> "I was again confirmed afterwards that [the scientists] really like this kind of thing [. . .] it's kind of like a little school trip for them. We get to go to Design!".
>
> (a designer)

5. Discussion

5.1. Storytelling for Inclusive and Creative Multidisciplinary Collaboration

The results validate the benefits of participatory storytelling as a method to facilitate multidisciplinary co-ideation that promotes creative thinking centered around the user perspective [34–36]. In particular, our research highlights the key role of stories as a universal and all-encompassing means of communication—a boundary object for creating dialogue—that enables a low threshold for participation and an inclusive atmosphere for participants from different backgrounds. This is a prerequisite for addressing complex sustainability issues. The imaginary component of the stories is instrumental to lowering the barrier for creative thinking and making the participants less judgmental. The playfulness of the method and its focus on creating stories while implicitly and naturally leading to inventions contributed to its engagement and accessibility. This results in the scientists and designers openly exchanging perspectives and building on each other's ideas—an integrated collaboration that transcends the compartmentalized interaction that is too often observed [10,19,26,28].

In terms of idea outcome, we expected the combination of the technical and user-centered expertise to result in novel or radical characteristics of the ideas [13]. However, the novelty of the ideas was not explicitly mentioned by the participants. The method did result in a broader range and a higher number of ideas than in workshops using other methods that the participants had experienced in the past; this is attributed to the combination of perspectives that favored the exploration of the application of technology in situations and areas that were not previously considered—for example, in different product categories or for new markets or user groups. There are two ways to achieve a high degree of novelty for a product: either by developing a new and unexpected solution to a known problem, or by addressing a new problem or one that no one has addressed before [22]. With the storytelling method, we achieved mostly the latter, because the reported strength of the method in driving problem ideation facilitated the identification and envisioning of unthought-of needs and problems in unexpected application areas for a technology—resulting in seeds for meaning-driven innovation [13]. The method also has the potential to contribute to the former, i.e., new solutions to known problems, by helping skilled technologists to ideate on problems contextualized by user-centered thinkers. However, the interviews revealed that the ideas could have been richer in their technological embodiments. This is needed to generate novel solutions to a known problem. Follow-up sessions are therefore desirable, to further iterate and deepen the ideas.

5.2. Storytelling to Integrate User-Centered Thinking in the Innovation Community

Our research shows the impact of shifting the mindset of scientists towards user-centered thinking in a commercial reality. Studies in educational environments have shown that design thinking favors the understanding of users' needs for technical professions [54,55], but we demonstrate that, in an industry innovation setting, where product or solution development may too often start from a technology angle [15], the storytelling method recenters early ideation around the needs and the experience of the user, resulting in ideas that are potentially more realistic, practical, relevant, and attractive.

Our study confirms the potential of storytelling to counteract the analytical and technical way of thinking in which scientists can get stuck due to their natural tendency and education [19,35,36]. Occasionally, as expected, the method was arduous for some scientists who were not used to this divergent, experiential, and emotional way of thinking [27]. Repeated exposure to the method could help to build familiarity with storytelling and greater ease when opening up to different perspectives.

We were surprised to hear that designers also may not always pay deserved attention to the user perspective. It is known that designers can get stuck in an analytical way of thinking [57,72] or adopt the "path-of-least-resistance", i.e., starting with situations most readily accessible to memory-like personal experiences or behaviors, before moving on to more original ideas [73]. Designers expressed that by applying our method, they were reminded of the importance of emotional aspects in the user experience and the communicative power of stories. Hence, it appears that both scientists and designers benefited from envisioning experiences beyond their own perspectives and what is practically possible at first sight. This was facilitated by the thorough detailing of personas and stories through the tools following the three-tensions framework, which enabled participants to achieve the level of depth needed to understand and empathize with the users and imagine the real-life consequences of the proposed ideas.

An interesting finding is that all but one of the scientists involved in the study reported that the method changed their mindset and way of working after the workshop. They shifted partially towards a problem-based approach instead of a technology-based one, and/or started adopting design tools in their projects. The durable uptake of design methods in organizational contexts and with the scientific environment has been identified as a challenge [22,27,28,53]. While it should be noted that we can only report on the participants' own assessment of their change, this is a promising finding. A long-term study recording the pre- and post-mindset of scientists participating in storytelling workshops should be conducted to validate these results. We can attribute this successful uptake of design thinking to several reasons.

First, the development of the method was naturally integrated into the innovation process and with other creative methods already used by the scientists. Paying attention to the actual needs of companies and ensuring a match between the method and other methods used is key to the uptake of design methods [53]. The method was inherently optimized to answer the need for the company to conduct explorative ideation starting from user needs instead of technology, yet grounding it in the technology. This required both the scientists and designers to be involved in the ideation and therefore a need to facilitate collaboration among the two expertise groups, which we achieved through using the storytelling methodology. The broad range and high number of generated ideas that formed innovation seeds fitting the company's strategic areas was valued by participants and is concrete evidence that also contributed to the method's uptake.

Second, our research shows that a particular advantage of the storytelling method compared to other design methods is the universality of its language and process, instead of specific design vocabulary and tools that might not resonate with non-designers. An appropriate complexity level and the use of a familiar vocabulary and taxonomy all contribute to a method's acceptance [53].

Third, it appears that storytelling has the potential to make design thinking accessible to scientists by reuniting analytical and intuitive thinking, because story building with our method can be approached with an analytical as well as an intuitive or emotional mindset. Our three-tension framework used in combination with the Freytag's story arc gives structure and order to the persona and story arc building, making it suitable for analytical minds. On the other side, the fictional stories trigger imagination and empathy to bring together elements of the experience rather than using analysis [35,37]. This dual approach may be another way to explain the success of storytelling to facilitate multidisciplinary ideation and to trigger the adoption of user-centered perspectives and tools amongst scientists. Eventually, this has the potential to favor the successful market imple-

mentation of sustainable innovation through a repositioning of technology developments and discoveries within the user's experience and context. For example, looking at complex and atypical personas can be valuable for inclusive design [74]; detailing the emotional and behavioral dynamics of the use of a product can provide information to build more engaging and effective circular solutions [12], or to identify new ways to diminish the energy consumption of a product [75].

5.3. Perception of the Collaboration and the Other Discipline

The method did not significantly change the perception of the roles of each profession, possibly because the participants in these workshops had interacted with the other discipline in the past. This builds on Goldberg, who found that long-term and regular interactions are beneficial to appreciating the skills and mindset of each discipline [19]. It is likely that this established understanding prior to the workshops facilitated the multidisciplinary collaboration by helping to overcome communication issues [10]. Nevertheless, the method reinforced the perception of the value of the collaboration and the intention to interact more frequently.

During the workshop, beyond the explicit formulation of ideas and insights, participants became tacitly familiar with other disciplines' way of thinking and creating. Storytelling is a way to capture tacit knowledge more efficiently than any other form of communication [37]. Moreover, unexpected situations further contribute to revealing tacit knowledge [20], and story building and telling is exciting and unusual for most participants, as shown in our study. The revelation and combination of this tacit knowledge in a multidisciplinary setting is a rare and precious event and was favored by our method. It contributed in real time to the generation of ideas that had never been expressed before. In the longer term, it formed a possible driver for the change in the scientists' mindset and way of working, as well as for the desire to reinforce interaction.

Noticeably, a shift in the designers towards a more technological or analytical mindset was not expressed in the interviews. Designers talk about design thinking as a discovery and innovation process, but research scientists have other ways to conduct problem solving and ideations. Even though we aimed to have an integrated process with equal contributions, the method still originates from a design perspective. The fact that none of the designers commented on the method's potential to force issues and conflicts can be explained by the fact that designers are already used to working from the user problem as a starting point. It would be interesting to extend this study beyond having scientists immersing themselves in the user-centered approach, to designers integrating the techniques of scientific innovation and building awareness on technological possibilities. For example, we could extend the three-tensions framework to include the technology tensions, embedding the technology and scientific insights to a greater degree. In the end, a combined creative process could emerge.

6. Conclusions and Future Research

Our results show that storytelling gives participants the room to speculate, the right to try, and to find space for original ideas and different perspectives. While this study focuses on the collaboration between scientists and designers, the universality of this method has the potential to make it successful with other types of experts and stakeholders. This exploration is a step towards integrated collaboration and perspective sharing between diverse disciplines, which is key when co-designing system transformation. We believe that storytelling has the potential to be a trigger for systemic change by facilitating this synergy; future research should explore this notion further [76]. Further, our method centered around the three-tension frameworks enables stakeholders to explore and build awareness on the contextual and social implications of new ideas, making it relevant for envisioning the implementation and implications of sustainable innovation.

One of the main strengths and originality of the storytelling method is that it is more a problem ideation tool than a solution ideation tool. Quoting a scientist in our study, "there

are other ways to do the other things [finding solutions], but I don't think there are a lot of other ways to force the problems." Thinking in terms of new problems is a route to unexpected innovative solutions. It is a way to uncover and anticipate user needs in areas where they are not well defined, such as in future scenarios and in complex ecosystems. The method's uniqueness could be a game changer in ideating successfully where other methods struggle—for example, in sustainable innovation, where seeking relevant user needs in system complexity and uncertainty has become more critical than ever.

Another direction that should be explored is how participatory storytelling, used generally as a carrier for people-centered thinking, can convey the "voice of the planet" [77,78] to create an emotional connection with the environment and elicit systemic awareness. This could help in creating a sense of urgency around environmental issues, as well as favoring the ideation of solutions where the environment is considered.

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Appendix A. Supplementary Information on the Data Collection

Questions Used during the Interviews

1. What do you remember from the workshop [date and topic of the workshop]?
2. Do you think that the storytelling method brings anything?
3. Let's talk about the concrete outcome: how would you describe the resulting ideas? Do you think they were different, better or worse, and how, than ideas from other brainstorms?
4. What tools do you usually use to do creative ideation? Do you get stuck somewhere where you think storytelling could help?
5. How did you experience the storytelling workshop, how did you feel during the workshop?
6. How did your experience the collaboration between designers and scientists during the workshop?
7. Has your perception of designers/scientists, their role and their contribution to innovation changed after the workshop? If yes, how?
8. Has your perception of user-centered thinking changed after the workshop? If yes, how? [only for scientists]
9. Has your mindset or your way of working changed after the workshop? If yes, how?
10. Do you have any other remarks, or a recommendation for improvements?

Table A1. Number of scientists' and designers' quotes for each theme.

		Number of Scientists' Quotes in This Theme	Number of Designers' Quotes in This Theme
Enablement of multidisciplinary creative collaboration	1. Multidisciplinary	21	12
	2. Inclusiveness	12	8
	3. Common language	6	10
	4. Engagement	21	15
	5. Accessibility	5	11
	6. Creativity	4	9
	7. Out of comfort zone	6	5
Promotion of user-centered thinking	8. User centered	16	16
	9. Persona	9	11
	10. Scenario	18	10
Range and type of generated ideas	11. Range of ideas	9	3
	12. Quantity of ideas	6	4
	13. Quality of ideas	9	2
Relevance of the tool in innovation	14. Where in the innovation process	9	2
	15. Business relevance	9	1
	16. Communicating to others	1	3
	17. Problem	15	1
Impact on mindset, perception, and way of working of participants	18. Changed way of working	18	11
	19. Changed perception	8	8

Table A2. Full conclusions and selected representative quotes from the interviews (the "conclusions" column condenses the answers of the interviewees with minimum rewording).

Theme	Conclusions	*Quote*
1. Multidisciplinary (bringing different people and expertise together)	Almost all participants stated that, in ideation, it was beneficial to bring together different perspectives and disciplines (research, business, design) and to set up a collaboration space where everyone could chip in with their expertise and insights. The interdisciplinary approach facilitated looking at problems from different angles and generating more varied insights. The storytelling facilitated this multidisciplinary collaboration.	*"When you come together with designers, with people in business, with people from research, I think that is where, you know, that's where the Magic happens"* (a scientist)
	Some differences between scientists and designers were highlighted, such as scientists looking more at how products work while designers looked at how products are used. One scientist and one designer recognized that there is a stereotyped perception of designers amongst scientists, where designers make "things look pretty" and think more "out of the box, creative and free-form", and that designers are not always considered when solutions have to be generated.	*"And I think it can help to make it a bit easier with people who are bit skeptical of the sort of skill sets that design brings to the table. Or you know, like I know there is a kind of stereotype in research that design, like if you want to get a pretty image or do something that looks pretty then you go to design. But if you really want to solve a problem then you wouldn't. Design won't always be invited to the table"* (a scientist)

Table A2. *Cont.*

Theme	Conclusions	*Quote*
2. **Inclusiveness (giving everyone an equal voice)**	There was consensus that the storytelling method enabled inclusiveness with respect to expertise or perspective, because every participant could easily translate their perspective through a story. It did not put more emphasis on the input of one particular person or group of persons with a given expertise—in contrast to workshops focused on one type of expertise, where participants with another type of expertise find it difficult to speak up. For example, in a technology-focused workshop, it might be difficult for non-technical people to contribute. In contrast, designers are often more talkative than scientists, who tend to internalize their thinking, which can create an imbalance. The storytelling method prevented having a dominant person or group taking over the discussion. Rather, people enhanced each other's ideas.	*"It's good to kind of mix them up a bit and, then again, because the way the method is scripted, you kind of empower everybody. Doesn't matter who contributes, it's not like a math problem where only the engineers are happy because they're consulted, and others feel left out"* (a scientist)
	It was suggested that storytelling broke down barriers for people to speak up because of the fictional nature of the character—everything was possible. All ideas or trains of thought were encouraged; there was no judgement—in contrast with other types of ideation that are framed in reality, where specific ideas can more easily be invalidated.	*"I felt all ideas or train of thoughts were very well encouraged. So there was no judgement. And I think potentially the storytelling helped there, because we were like thinking about: oh yeah, a fictive character. Yeah. So it was not that there was one specific idea based on previous experience or an interview that may be invalid; everything was possible because it referred to a specific, fictive person"* (a designer)
	One participant said that storytelling is more objective than ideation based on marketing results, because marketing personas bring in a bias while imaginary personas give more freedom when imagining their response.	
3. **Common language during workshop**	Most interviewees acknowledged that storytelling helped participants communicate their ideas in an understandable way because they were embedded in a story's context. People with different expertise think very differently—for example, workflows or other design methods might be difficult for scientists to comprehend—while everyone can grasp a story and add to it. It got participants on the same page, gave them common ground, and helped them look at things from different perspectives.	*"Today so many people do this with these, you know, workflows or other design methods that we have. But I can imagine that for scientists it's actually quite hard to comprehend. And then the story, that's something that basically everyone can grasp and then add to"* (a scientist)
	Storytelling is a fun and common language that created a natural conversation flow. The conversations were started more easily.	*"The flow of the workshop was very natural, and it helped to align and to find common ground in thinking about these ideas"* (a designer)
	Scientists tend to go into details quickly, and the storytelling helped to keep a golden thread through the discussion.	*"I think it really is hard to put words to it, but I really think it helps them to not go into too much detail not to feel like they're out of their depth [. . .] it's just having a kind of a lifeline to hold up through this story"* (a designer)

Table A2. *Cont.*

Theme	Conclusions	*Quote*
4. **Emotional engagement during workshop**	In general, the participants perceived the workshops as fun, playful, laid-back, relaxed, and exciting, with a positive and energizing atmosphere. They were highly engaged and motivated to participate and empowered in providing contributions.	*"It makes people curious, [. . .] they started to have fun. I felt empowered, excited. [. . .] I was at a party!"* (a scientist)
	Several factors were mentioned that contributed to this high engagement. First, playfulness helped participants to bond—the story building acted as an icebreaker that helped to take people out of their comfort zone. Second, people were motivated to participate beforehand; they were curious. Several participants suggested that the method was exciting and engaging because it was a new method—people might be tired of "classical" post-it-based brainstorms. Third, the introduction presentations were of high quality and enjoyable.	
	Several interviewees said that there was a good flow that made the workshops less exhausting than other workshops.	
	One scientist found the real-life workshop tiring because of the continuous and high-energy engagement required; still, they were happy to engage with the team. For the online workshop, which was shorter, one scientist mentioned that there was too much time pressure and another scientist felt that the "flow of emotion" and the interaction between people was not optimal.	*"So for me these were quite exhausting days. You have to be really engaged and that engagement, yeah, it takes quite a quite a lot of energy if you want to be fully engaged. I'm also a fan of like this workshop event and you need it if you really want to get something done. I was happy to engage, engage with the team"* (a scientist)
5. **Accessibility of method (cognitive engagement during workshop)**	It was clear from the answers that building or telling a story has a low threshold for people. "*Everybody watches movies*", so it was very easy to for people to understand the method. The process of story building had clear guidelines, which made it very easy to understand what to do. It was a quick way to get people on board, to put people in the right mood and creative mindset. The process happened naturally; it did not feel like a typical ideation session.	*"I'm bad at drawing and you know I would do it. But telling a story or coming up with a story is actually maybe a lower threshold for a lot of people, so [. . .] you have more people in the creative mindset"* (a designer)
	Several interviewees mentioned that good preparation of the workshop, some conditioning of the participants beforehand, and a good introduction to give background information on the methodology were key enablers for success. The introduction on storytelling already helped to trigger discussion, instead of a classical ideation in which participants must start brainstorming when told to.	*"Normally you have a workshop and then people say OK start brainstorming. It's not a button!"* (a scientist)
	However, the process was difficult for some participants. One scientist said that it was sometimes a lot to follow and that he needed mental breaks. One designer mentioned that writing a story from the user's perspective is very difficult, because people like to make statements that fit into their own worldview and stick to their field of expertise. Moreover, the ability to be empathetic is very person-dependent. There is a need to bring people into a true people-centric and storytelling mindset, and the designer hypothesized that a one-day workshop might not always be enough to achieve this change.	*"You really need to sort of change the mindset of people in order for them to be able to understand what it is that you're trying to do" (a designer). "Sometimes there was a bit too much in the sense that I could not follow. I had to take a mental break"* (a scientist)

Table A2. *Cont.*

Theme	Conclusions	*Quote*
6. Creativity (triggering outside-the-box thinking—a different approach to ideation)	Because the stories were imaginary, participants thought outside the box more easily. Storytelling facilitated out of the box ideas by taking away barriers—such as focusing on what is technically possible or not—and favored an open, creative mindset.	*"I feel like otherwise you will easily get trapped in a more technological discussion, potentially also hindered by what is possible and what's not possible this far"* (a designer)
	Participants combined these out-of-the-box, unexpected ideas with expertise, resulting in exciting new directions. It also facilitated the combination of ideas and formation of connections that would not be seen otherwise.	*"We came up with crazy stuff. [. . .] as researchers can be, they can be very excited about a specific detail, and then when they put it into a story, it's actually quite an interesting concept or idea"* (a designer)
	Designers and scientists expressed that, for someone who has been working on a topic for a long time, using the storytelling method with people who look at the topic in a different way brings a new perspective and enables a different way of thinking. It happens to some extent in any co-creation session, but the storytelling enhances this new perspective taking. A participant also mentioned that storytelling can help when one gets stuck in an ideation stage.	*"What often happens and especially when you're so deep in the topic, [. . .] you create this one directional way of thinking [. . .] and then it's always good, once in a while, to have other people looking at that completely differently so that you know: OK, I have to open up again because I'm focusing too much again on the topic [. . .] I think it happens in any cocreation session. But I think what happened here is because of the storytelling"* (a scientist)
	Besides the active story building process, just listening to a story triggered discussion.	*"So someone was telling a story about a certain situation and then you saw that on the other side of the room. Another one said like, Oh yeah, but how about you doing this? Or how would you do that?"* (a designer)
7. Out of comfort zone and of usual way of working	Storytelling is not something that people do daily; it took participants out of their comfort zone. It forced them to step out of their bubble of expertise (technical, design, clinical, etc.) because the stories were all-encompassing. Furthermore, it involved brainstorming with different disciplines, which is not always common practice and was "refreshing".	*"I think it this famous thing of taking people out of their comfort zone. I think you can definitely achieve that with this approach. Because it takes them out of the technology bubble or the doctor bubble or whatever bubble they're in, it takes them out of that bubble and it forces them to try to take that other perspective, even if it's only for a few hours"* (a designer)
	For designers, storytelling is close to what they usually do and feels natural to their generally more extrovert or creative nature.	
	Scientists normally work based on literature, data, and evidence, and storytelling allowed them to think beyond that. This could be helpful, for example, in coming up with ecosystem solutions, which are usually broader than the one activity on which a typical expert focuses on.	
	In business, ideations are not common, but they usually integrate the customer perspective by using market analysis tools such as analytics data or customer reviews. From these, they evaluate where they can improve to come up with the next steps in the product and business models. Tools such as storytelling are also used in marketing. However, ideations are usually organized around existing activities or current business operations, with specifiable problems statements, and are aimed at imagining propositions to solve these problems. Our storytelling methodology is different because it focuses on problem finding or need-seeking. It is a complementary approach to traditional brainstorms, where participants spend most of the time coming up with potential solutions.	*"The strongest part is problem finding or need-seeking aspect and that's really different to any other workshop. It sometimes surprises me that you come up with inventions because actually you don't spend a lot of the workshop focusing on the invention"* (a scientist)

Table A2. *Cont.*

Theme	Conclusions	*Quote*
8. User-centered mindset (meaningful vs. technical)	All participants mentioned that the method helped in bringing a user perspective to the ideation. For most of the interviewees, this was a contrast from other ideations that very often start from a specific technology, a use case related to that technology, or a technological problem. The scenarios in the storytelling workshop did not address a technical capability. They made people focus holistically on the whole customer experience and needs and on the usage of the product in real-life scenarios. By doing so, they helped to improve on the interaction, usability, attractiveness, and usefulness of a product for an audience.	*"It's a completely different angle than this technology push, this is something I think that we do too much in research, that we have a certain technology and then we're going to look: OK., where does it fit? Now we have a problem, and whatever technology or method can be applied there is all open, and I think that's my sort of takeaway message. [. . .] This is also, yeah, almost the most important thing if you want to create something for people; you first have to study the people that you're designing for, developing for" (a scientist)* *"Many designers initially are very much thinking about [. . .] cool stuff they can make, but not always useful ones. [. . .] It's more in the line of thinking 'because we can', not necessarily because it's going to help users"* (a designer)
	Storytelling brought the ideas that the participants have with the perspective and context of the user in mind. It enabled the determination of whether ideas are relevant and practical or not.	*"What I think it really brings is having to step out of the theoretical sphere and really look at something that gives you more information, more point of view from practice. So that's one, and the other is actually having to think about people. So really, the story is about a person and you have to use empathy; you have to project your point of view from the point of view of that person. So that's also something that's really strong in this methodology"* (a designer)
	Especially for scientists, technologists, and developers, it is difficult not to forget to bring the user in, to consider the emotional benefits and other design aspects. Forcing them to be in the shoes of the persona made the emotion of the journey flow in a more natural way. Many interviewees mentioned that scientists thoroughly enjoy being brought out of their technological sphere to a user-centered perspective (be it storytelling workshops, field trips, or discussions with real users).	*"I deal with a lot of developers and they are really good at putting a certain functionality in the app code and they just push it in. But then it makes more sense to also look at the customer, how the customer actually uses this feature"* (a business lead)
	Several designers mentioned that designers also can have a technological mindset and may lack the user-centered focus when approaching ideation: they initially think about what they can make—because it is "cool" and because "they can"—but not necessarily about useful products that would help users.	*"I feel like otherwise you will easily get trapped in like a more technological discussion"* (a designer)
9. Persona (stepping in the user shoes and building empathy)	The benefit of using the detailed personas in the process was clearly acknowledged. Focusing on a specific persona's life (e.g., a patient, a care professional) helped participants take different perspectives, to take the user's point. The story brought the personas to life. It forced participants to think about how their ideas may fit into that specific individual's journey, what would their real-life experience be, issues, and relationships with other people. By "being in the shoes" or "being in the skin" of a particular type of persona, participants understood them deeply and truly empathized.	*"Let's not understand them [the personas] as an object, but try to understand them from the inside out. Well, that's what storytelling does"* (a designer)
	It helped to have different personas (e.g., several types of users) to obtain different perspectives and make the participants aware of the differences, and then to focus within a breakout team on one persona. It prevented getting stuck with a specific persona's issue and targeting the ideas around that issue.	
	Empathizing with the user through the use of personas led to identification of realistic ideas and opportunities.	

Table A2. *Cont.*

Theme	Conclusions	*Quote*
10. **Scenario (acting out and in context)**	Going through scenarios, into the real-life situation of a persona using or experiencing an existing or future product or service, did help ideation. It triggered discussion and inspired people to come up with new ideas. Several interviewees compared it to experiencing a real product. It forced the participants to think about the consequences of their ideas in real life and see what works or not in reality. A business interviewee wished that going into experience scenarios would be used more often in development processes.	*"You're forcing people to think what the consequences are of doing this. And yeah, you sort of might find out that the consequence doesn't work unless you do something. So, to me, that's always been the strongest part of the storytelling"* (a scientist)
	Several participants stated that ideating based on scenarios did not feel like a typical way of ideating where one finds solutions for a problem, but that it embedded the relevant context around the problem.	*"[usually] this is the problem and now solve it. Right, so I think that's more, I don't know, it's like in a vacuum that is presented normally and now it's not a vacuum. You have all of the data sort of around it."* (a scientist)
	A designer expressed that scenarios are a better way to share user insights than the experience flows typically used in user research. He explained that experience flows are difficult to comprehend because they are too rich—unless one is already very deep in the topic—and that people get lost in the details. On the contrary, he said that scenarios are a way to tailor the experience data that one wants to share.	*"You're tempted to put the whole thing [experience flows] because A, that's what you have and B, everything is in there. So basically, it's not tailoring your methodology to what's exactly needed, but just taking what you have; either nothing or not fitting. And that's what I experience with this process. It fits exactly because you made the story and all the inputs specifically for this process, and that works really well"* (a designer)
	Another benefit mentioned is that participants were able to map their own experience on the topic onto the story.	
	It appeared that the fact that participants embodied a situation not by using words, but by using gestures and acting out, made them experience a certain problem at a different level.	*"And that was a very hands-on workshop. So it wasn't just storytelling, it was really what do you call it? Body storming or something like that? So we really acted out scenes and [. . .] I think that that's the thing I remember most about that, when I think compared to other sessions I've been involved in, we acted out more scenarios and that was really, really useful"* (a scientist)
	Several designers and scientists noted the importance of having the scenarios based on enough real experience data gathered, e.g., from interviews or psychological research data. At the same time, they did not need to be perfectly accurate if they were a support or ideation, but rather described a "day in the life" of the persona with enough depth to trigger ideation. A designer suggested to back the story building with more scientific evidence in terms of psychology.	*"And also there if you get 80% right, it's fine. It's fine, and if your story wasn't 100% perfect, you get some weird ideas or anything, [. . .] it doesn't really matter, so there's a big gray area in how accurate your story has to be, as long as it's a good story and gives you a lot of cues to ideate on. And it did"* (a designer)

Table A2. *Cont.*

Theme	Conclusions	*Quote*
	Most interviewees—especially scientists—stated that the scope of ideas was broader, and the ideas were more diverse than in usual ideation sessions. This was attributed to the participants in the brainstorms thinking about situations or areas that they did not consider exploring beforehand—in contrast with a traditional approach, where the problem is very scoped, and the boundaries are very well defined.	*"It's richer, it maybe gives you more avenues for coming up with ideas [. . .]. You start to see: oh yeah, well, this might connect with this and there's a whole story around it. So then you say: oh well, I can approach it from different angles"* (a scientist)
11. **Range of ideas (broader scope, different type)**	Interviewee answers converged to say that storytelling is about seeing the big picture. The ideas were more connected to other services or platforms because participants thought more broadly and beyond the main problem. The range of ideas was also broader because storytelling makes the participants less hindered by what is possible and what is not possible this far.	
	Scientists and designers recognized that the storytelling set-up is oriented at creating UX ideas, which made them different from ideas generated in traditional brainstorms because creating user experience ideas is uncommon.	
12. **Quantity of ideas**	Many interviews stated that the storytelling workshops were very productive; they generated more ideas than traditional ideation.	*"It was a kind of a pressure cooker workshop, so I was impressed by the number of ideas we had in so little time"* (a designer)
13. **Quality of ideas (high level, more thought-through, farfetched)**	Some participants thought that the ideas were more thought-through, while some thought that the ideas were less complex and less concrete than with other ideation methods. The idea quality and value seemed to benefit from the fact that participants enhanced each other's ideas through the storytelling process. The lowest complexity would come from the fact the participants did not go really deep in detailing the ideas, but rather focused on the situation and on the experience. A one-day workshop was too short to bring the high-level ideas to detailed propositions, and the rough ideas needed to be worked out in more detail afterwards. A scientist missed the technological depth during the ideation but was able to chip in later when the ideas were deepened.	*"Yeah, so I think they these are more thought through. [In traditional workshops], the ideas are typically from like one or two people initially, so the background of the idea is typically very small. In the storytelling workshop everyone is aligned in the story, and we give input in the story I feel the background for the ideas is a lot richer" (a scientist)* *"Yeah, maybe the complexity of the ideas is lower that you come up. Which is maybe also one of the weaknesses of the approach. You know you don't, you never go really deep, you go very deep in the situations and in the experience"* (a scientist)
	Several scientists and designers observed that even if, initially, the quality of the raw ideas was heterogeneous, after selection, there were more high-quality, high-value ideas than in a typical brainstorm because of the large number of ideas generated.	*"I think that the quality was a bit less than I expected, but that was compensated by the amount"* (a designer)
	One interviewee found that some ideas were more far-fetched than usual, which he attributed to storytelling bringing participants out of their comfort zone.	

Table A2. *Cont.*

Theme	Conclusions	*Quote*
14. Where in the innovation process	Many scientists regretted that, in innovation environments, the fundamental reason for developing a technology is not always there. The approach in product innovation is too often to draft a technology, to go through the development process, and finally to position the product in the market by looking at the problems it can solve. This approach may result in low resonance of the product with the users and a potential product fail. It is important to first identify the user problems, which is what the storytelling methodology does. Storytelling can be used to identify the user's problems that should be solved by a technological innovation.	*"I sometimes see that they created technology and after that, they start looking: OK, so what kind of problem can I solve? [. . .] Often you also see that ending up in the bin"* (a scientist)
	Several scientists found that storytelling is a good tool for exploration, at the start of the innovation journey.	
	A scientist and a designer thought that storytelling can enhance the experiential, visual brainstorm around a real product or a wireframe by making problems from a user perspective more visible. It can help to replace this type of physical brainstorm in digital, remote brainstorms. Storytelling could be used as a pre-test in early prototypes to gather preliminary user insights before testing with real users.	*"If you can't touch the apparatus and be there in the hospital and see what it is, by telling the story you bring the problems more to life. [. . .] I think storytelling can maybe help compensate a bit [for the virtual collaboration that is a challenge]"* (a scientist)
	One scientist said that storytelling can be used for product roadmap building: it enables ideation on future users' target groups and their pain points, which can then be prioritized and used to set the scene for a solution roadmap ideation.	
	One scientist said that storytelling helps for ecosystem innovation, where there is no clear existing business, or any defined problems (an area where traditional methods would not suffice).	
	Another angle mentioned by several scientists was that by identifying new problems, storytelling can help find new general solutions for certain needs that are novel enough to allow patentability.	
15. Business relevance	According to the interviewees, the main business benefit of storytelling is its collaborative power. Storytelling can help bring various teams and stakeholders together to bring awareness about the real issues of the user and how to solve them, in order to understand the relevant gaps or opportunities to be pursued.	*"There are many different stakeholders, and I think something like this would really help everybody get more awareness about what the problem is"* (a scientist)
	One scientist said that storytelling forces people to come up with propositions rather than standalone solutions.	
	One interviewee working in marketing thought that storytelling can support marketers in understanding how real users would use a product, in order to optimize the customer fit or to validate certain marketing ideas. Moreover, businesses often focus on the biggest target group that can yield the best revenue, but storytelling can help identify new, maybe smaller, customer groups with high margins. One designer shared similar thoughts that storytelling can help in finding new markets for a product or a technology by taking an existing product out of context to unexpected application areas.	

Table A2. *Cont.*

Theme	Conclusions	*Quote*
16. Conveying/communicating ideas to others outside the workshop	Some scientists and designers mentioned that stories are a good way to communicate information and ideas—for example, when following up or reporting on some concepts. It is easier to explain the idea and how it came to be in the context of a story and from the perspective of a person.	*"Sometimes [. . .] if you look at the specific idea like that, it's quite specific or random. But now, because he told the story, you can actually see how it came to be and what it's like in context"* (a designer)
17. Problem ideation	Most of the scientists appreciated that the method forces issues and conflicts to focus the ideation and create the solutions. If participants stay in the "happy flow" of the story, there is no problem and there is nothing to solve. The storytelling makes problems of the user and the causes of those problems more visible and tangible. By introducing problems and dilemmas in the scenarios, participants feel the struggle that the users may have in daily life; they discover new issues and pain points during product use, and eventually come up with new ideas.	*"The issue that a person is facing, and if you can capture that well and you have also to say that in confidence this is an issue that we need to tackle, then start the ideation. It should be, I would say, almost the method or the standard method for ideations"* (a scientist)
	Several interviewees said that storytelling is a unique and powerful tool for finding problems and is a complementary method to other tools for solution ideation.	*"I still think that finding the problem is sort of the unique part of it. And I'm sure there are other ways to do the other things [finding solutions], but I don't think there are a lot of other ways to force the problems"* (a scientist)
	Only the scientists and no designers mentioned problem ideation as an aspect of the storytelling method.	
18. Changed way of working and mindset after the workshop	The workshop showed that there is room for new ways to collaborate and ideate and triggered many participants to learn more about different tools related to storytelling.	*"My mindset has I think a bit opened. You can see that there are other ways to collaborate and ideate [. . .] in general more than what we normally do in Design, right? We always have the same types of workshops. And I think this really shows that there is room for innovation here as well to come up with new ways of doing this"* (a designer)
	The workshop was a trigger for most of the scientists to start implementing design tools in workshops. such as persona, metaphors, system maps, on top of the traditional ways of brainstorming they were already using (TRIZ, etc.). The storytelling method made them realize or reinforced their perception that there is value in taking a user-centered approach and in starting ideation from problems instead of technology. Only one scientist did not change their WoW or mindset after the workshop.	*"[before the storytelling workshop] my mindset was also, let's come up with something, let's invent, let's try design or create and then test. Now I first start, OK What do we need to show? What's the key problem that we need to solve? I think that really changed in my perception"* (a scientist)
	After the workshop, several designers started using personas and empathic story-building tools to incorporate the experience part to a higher degree into their design research work or in their communication. A designer explained that many designers tend to leave out the emotional part and that storytelling can fill this gap.	
	After the workshop, several scientists and business stakeholders reported that they encouraged their teams to try and use products and prototypes to get a realistic feel and share their experience.	
	A scientist explained that the way of working and ideating in innovation has changed completely in the last 5 years, from "inventing a device in a box" to a blend of digital, ecosystem, and hardware, and that storytelling is needed in this new innovation mindset.	

Table A2. *Cont.*

Theme	Conclusions	*Quote*
19. Changed perception of others after the workshop	Most participants did not significantly change their perceptions of the other roles (scientist, designer) because they had interacted or worked together in the past.	
	However, several participants better understood the roles of people with other expertise, realized the value of having different types of expertise work together, and were triggered to do it more in future projects.	
	Several designers were surprised and realized that scientists can be creative and excited about this type of ideation.	*"I was again confirmed afterwards that [the scientists] really like this kind of thing [. . .] it's kind of like a little school trip for them. We get to go to design!"* (a designer)

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