



# Once Upon a Data Story: A Preliminary Design Space for Immersive Data Storytelling

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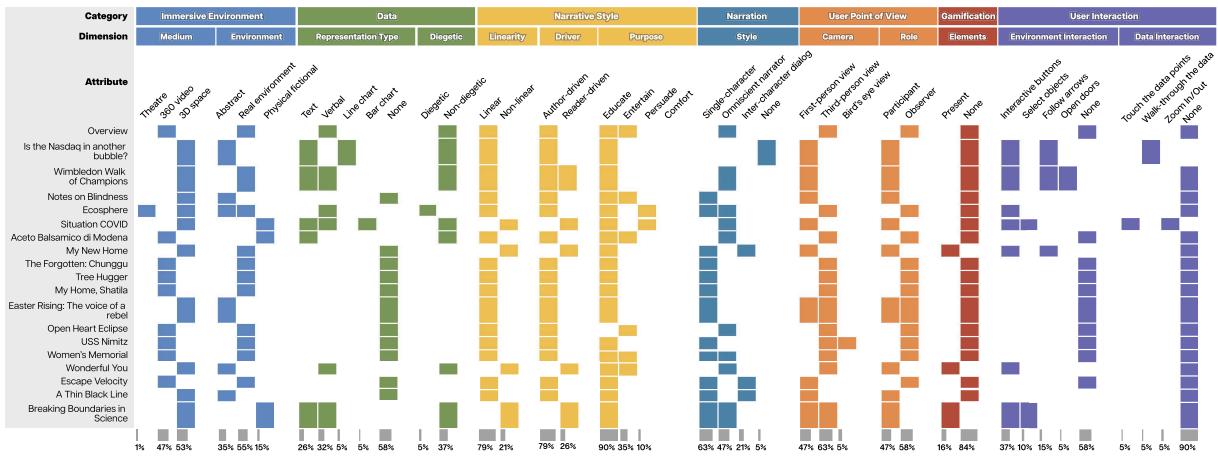
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**Figure 1:** The preliminary immersive data story design space highlighting our findings on each dimension based on the analysis of nineteen immersive data stories, which resulted in thirteen dimensions across seven categories.

## Abstract

Immersive data storytelling is an emerging field that combines narrative visualisation and immersive analytics to engage an audience. While there are existing design spaces for narrative visualisation on 2D displays, there are no guidelines for creating immersive data stories, making it difficult for practitioners and researchers to explore this space. In this paper, we present a preliminary design space for immersive data storytelling that is informed by current practices and multi-disciplinary views. We interviewed multi-disciplinary experts, including museum designers, architects, and game designers, to understand how they communicate stories in physical spaces and immersive mediums. We applied inductive thematic analysis to the interview responses to inform the dimensions of the design space and analysed a systematic selection of publicly available immersive stories. In the end, we had 13 dimensions in 7 categories.

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We present insights into this design space as common practice or areas for future research.

## CCS Concepts

- Human-centered computing → Virtual reality.

## Keywords

Human-Computer Interaction, Virtual Reality, Meta-Analysis/Literature Survey

## ACM Reference Format:

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## 1 Introduction

Immersive storytelling integrates the principles of traditional storytelling techniques with digital components, such as audio and video, and leverages immersive technologies, including virtual reality (VR) and augmented reality (AR) [2, 31]. Unlike conventional

storytelling, which typically centres around a defined theme and perspective, immersive storytelling can prioritise interaction, multi-sensory engagement, beyond-the-desktop [18] displays, and the provision of a unique user perspective, facilitating the exploration of diverse narrative structures. Immersive storytelling is used in various fields, including healthcare [13, 14], education [7, 20, 36], military [5], and journalism [12].

Narrative visualisation [32] combines data visualisations with storytelling techniques such as sequencing, narration and pacing [32] to communicate a consistent and coherent data-based narrative in an engaging way. We posit that there is a natural progression from narrative visualisation to immersive storytelling. Isenberg et al. [16] follow this progression by defining *immersive visual data stories*, which focuses on visual representations and the broader meaning of immersion relative to: *enhancing engagement* with data stories, *sense of absorption, emotional connection, and social presence* through immersive technologies.

For our purposes, we define "Immersive Data Storytelling" as the *act* of storytelling and *use* of information visualisation techniques to convey data insights in immersive environments across the Reality-Virtuality continuum [26], encompassing both *visual, auditory, and multi-sensory* modalities. Our initial exploration focuses on Virtual Reality (VR) due to the relative maturity of the technology. Despite the potential applications, immersive data storytelling is relatively under-explored. There is also a limited understanding towards the classification or taxonomy of what makes an effective immersive data story. Storytellers who wish to craft an immersive data story are required to primarily rely on past practice, trial and error or sparse literature searches on immersive visualisation. We also found that design spaces, as a prevalent tool for informing the design of artefacts, do not exist within the context of immersive technologies for data storytelling.

In this work, we present a preliminary design space for immersive data storytelling, which aims to bridge the gap between immersive storytelling and narrative visualisation. To achieve this, we explore two related questions: first, *what multi-disciplinary insights can inform the design of immersive data stories?* Respectively, many disciplines, including museum curators, architects, and game-level designers, often deal with configuring physical spaces and supporting storytelling in those spaces. Through semi-structured interviews with multi-disciplinary experts, we gathered insights into factors affecting user experience, engagement, and interaction in both physical and digital storytelling spaces. Second, *what is the current state-of-the-art in immersive data storytelling?* Informed by the multi-disciplinary interviews, we studied 19 publicly accessible immersive data stories and synthesised a preliminary design space for immersive data storytelling.

As such, this paper's contribution is a preliminary design space that integrates expert interviews and the current state-of-the-art immersive storytelling accessible by the public by analysing examples from the Meta Quest Store. Our design space identifies common trends in immersive data storytelling and provokes opportunities for future research avenues.

## 2 Related Work

### 2.1 Non-Immersive Data Storytelling

Data storytelling within non-immersive contexts (desktop, paper-based mediums) continues to be an established research topic between the visualisation and HCI community. Data storytelling is a structured approach combining data, visuals, and narratives to communicate insights derived from data effectively [11]. Zang et al. [40] presented a framework for data storytelling, which is the continuation of their previous work [38, 39] where the authors discuss multidisciplinary facets of data storytelling and share an overview of the design principles based on human cognition and motivation. Existing work has also explored the design space of data storytelling used in practice by looking at existing examples. For instance, Ojo and Heravi [28] studied 44 award-winning data stories between 2013 and 2016. The "Data-driven story" book by Riche et al. [30] provides a wealth of knowledge into data storytelling in non-immersive environments.

### 2.2 Immersive Data Storytelling

While there is well-established research in developing design spaces and frameworks for immersive storytelling and conventional storytelling methods such as cinema, games, and comics [1, 8, 15, 19], immersive "data" storytelling remains under-explored. The closely related topic of Immersive Analytics [4, 10] concerns the use of embodied data analytics tools in immersive environments to understand the data and make informed decisions. Immersive Analytics is primarily motivated towards "removing the physical barrier of the computer screen and mouse that exists between people and their data." The key difference between immersive analytics and immersive data storytelling is that the former encompasses a broad workflow of data analytics, while the latter focuses on presenting information (often insights from the analysis).

A few works in the domain of immersive data storytelling exist. In the Immersive Analytics book [25], there is a chapter for immersive visual data stories [17]. The chapter concentrates on the role of immersion and future research questions. Other works look at authoring tools [29], visceral sensation [21], cinematic narrative visualisation [6], and immersive humanitarian data storytelling [9].

Despite that, there is a gap in the current literature regarding how immersive data stories, especially state-of-the-art examples in VR, have been used in practice and the prevalent design patterns between them. For example, "How many immersive data stories are contemporaneously existing and accessible to users?" and "How can we examine these examples?" To answer these questions, we aimed to formulate a design space informed by interviews with experts and an investigation of VR applications in the Meta Quest store to examine the state-of-the-art accessible to the public.

## 3 Multi-Disciplinary Storytelling Interviews

We conducted semi-structured interviews with experts across several disciplines (see Table 1) that deal with storytelling in physical spaces. We sought to recruit experts from multiple disciplines to get diverse perspectives from professionals such as Architects, game designers, museum designers, and filmmakers, who are experienced

**Table 1: Demographics of the eight multi-disciplinary experts we interviewed to inform the design space.**

ID	Experience	Years Exp.	Gender
[muse]	Science communication museum exhibition designer	17	Female
[jour]	Journalist and academic in immersive journalism	10	Male
[stor]	Creative and screenwriter	30	Female
[arch]	Professor in Architecture	20+	Male
[desi]	Professor and practitioner in communication design	30+	Male
[desi2]	Professor in serious games and digital heritage	23	Male
[game]	Game designer and developer	22	Male
[film]	Traditional and immersive film director	24	Male

in designing physical spaces that create a sense of flow and movement. Also, they are experts at creating interactive spaces that evoke emotions and engage the users with a narrative. They consider user experience, engagement and storytelling elements while creating immersive games, architectures or films. Therefore, they can provide valuable insights regarding designing a design space for immersive data storytelling.

Interviewed experts were identified through professional networks and chosen based on their area of expertise and their availability to participate in the interview. Each interview lasted for 45–60 minutes. Eight experts were interviewed, and audio of their interviews was recorded and transcribed. NVivo<sup>1</sup> was used to run inductive thematic analysis on the interview responses.

### 3.1 Key Findings

The interview analysis resulted in 9 key themes around storytelling in physical or immersive environments. This section briefly explains each of the identified themes and also presents the quotes from the multidisciplinary experts supporting the themes:

*The soundscape is crucial to immersing the user in the environment.* One of the interviewees noted, "When there's just silence, the viewer gets bored quite quickly" [jour]. Sound can also be used to draw people's attention in immersive environments [film].

*The voice-over also plays an important part in engaging users in an immersive story.* One of the interviewees indicated that having voice-over narration is better than having images. "One of the things that we've learned as well is, rather than a straight interview, voice overs are often more powerful than having really evocative shots" [jour].

*Camera angle and positioning is a significant aspect of effective immersive storytelling.* Various camera angles, such as first-person, third-person, and bird's-eye views, offer different perspectives in immersive storytelling. For example, a low angle can emphasise the viewpoint of a child by making others appear taller, "If you want to have that omniscient view where the viewer feels they're above and have a sense of power, then you'll use the tripod ... at about two meters and that way, they can kind of look down on the

action" [jour]. Established cinematic techniques, like a slow push to build tension, can also enhance immersive experiences [film].

*Using the space cleverly is another important aspect of effective immersive storytelling.* It's crucial to create areas where users can easily find and process information, rather than overcrowding the space. "It's not about filling out the space. You need places for people to breathe. Patterns that give people an opportunity to identify the information that's important, rather than you just sort of filling the space within for information that you're not going to find." [arch]. Adding white space or negative space could be a good approach as it will allow the user sometime to comprehend the story and give some mental space to them. "Conceptual space, so leaving pauses in time or white space between ideas. There's a mental space" [desi].

*Gamifying an immersive story can increase engagement.* "So going back to your original question was ways of keeping player engagement. A good one might be to gamify it" [game]. "Storytelling is that there is that potential for the viewer to participate in it, to choose. So there's, you know, something of the gamification of it where they can choose to open this story or to open that door or to go over here or not, and I think that that's one of the really powerful elements of VR storytelling" [jour]. "I think games have done a really good job of putting people in stories. Virtual reality will take it, if done correctly, so much further, but I just don't think we know how to do that properly yet" [film]. There are two major components of gamifying any immersive story, reward and progression of the story. The user must receive some reward or be allowed to progress into the story after finishing a certain task in the story. "So you kind of get this reward even if you're trying to break the system and make the poor choices, you'll get like some sort of feedback and reward from that" [muse].

*Consider diegetic methods for representing data in virtual environments.* Instead of traditional charts, data in immersive stories can be presented as "physicalisations" or visual metaphors within the environment. These can be diegetic (part of the scene) or non-diegetic (external to the scene): "instead of using traditional visualisations in the VR, we could use different landscapes, terrains, clouds, etc to represent different types of data" [desi2].

*Keep immersive data stories within 6–8 minutes.* Experts recommend limiting immersive stories to six minutes, with scenes no longer than 30 seconds, as longer duration can cause users to lose interest. "We use 6-minute stories, and we generally say scenes of no more than 30 seconds. The momentum carries the viewer through really quickly" [jour].

*Define the viewer's role within the story.* Clearly establishing whether the user is a participant or an observer is crucial, as this shapes their interaction with the story. Four out of eight experts emphasised the importance of defining the user's role early on. "You need to define early on what the role of the viewer is within the story. So are they a participant? Are they an observer? Whatever it might be, defining the role, defines how the interaction can take place, so if the viewer is just meant to be an observer, then there might be 2 characters who are doing something or going somewhere and that movement" [jour]. The immersive experience should be tailored to the user's perspective, with factors like camera angle influencing

<sup>1</sup><https://lumivero.com/products/nvivo/>

their role, such as using a third-person view for an observer. "Again, if you went as a civilian and saw the same exhibition but see it from the civilian's perspective. To the idea of tailoring the narrative, depending on your perspective" [desi].

*Interaction is something that sets immersive stories apart from traditional storytelling methods.* Interactive elements like buttons, arrows, and doors create engaging environments. "And the other element that we insist on is that there has to be one level of interactivity as well, so immersed VR has interactive hot spots, which allows the viewer a sense of choice, and I think that that's one of the really important parts of VR" [jour]. One of the experts talked about data interaction: "you could sit within the data. The other space, you could actually walk into it and be surrounded by it. At other times, you might want to inform something else you're doing, so you might want it to be in a discrete part of your vision" [desi].

## 4 Design Space

We created a preliminary design space for immersive data storytelling by combining insights from our domain expert elicitation, existing data story design spaces, and analysis of immersive stories and data stories. The domain expert elicitation motivates immersive aspects of our design space. For the data storytelling aspects of our design space, we synthesise from three key works: Segel and Heer [32], Cao et al. [3] and Ojo and Heravi [28].

### 4.1 Immersive Story Collection and Analysis

We used the Meta Quest Store<sup>2</sup> as our database to collect immersive experiences, as it is currently one of the most prevalent VR application markets. We conducted a more inclusive search to also include non-fictional immersive stories due to two reasons: 1) while examples of immersive data storytelling exist, the practice is still maturing, and 2) we argue the design dimensions of non-fictional immersive stories can be tailored towards immersive data stories. We used the following search terms: "data stories", "data visualisation", "immersive data stories", "360 data videos", "immersive stories", "stories", "journalism", "documentary", "360 videos", and "educational stories". Sixty experiences were collected. We filtered out fictional stories, games, applications with technical issues, and utility applications. This resulted in a total of 19 immersive stories for analysis. The primary author experienced all identified stories in VR and initially encoded them using Notion [27], which all the investigators then refined.

### 4.2 Results

The analysis of the domain expert interview resulted in nine themes, which were then used to explore the design space for immersive data storytelling, combining it with the analysis of the 19 public immersive videos and the existing storytelling frameworks. We identified thirteen dimensions, grouped into seven categories (Figure 1), that form a preliminary design space for immersive data storytelling:

#### Immersive Environment

<sup>2</sup><https://www.meta.com/en-gb/experiences/>

Almost half of the 19 immersive stories use 360 video as their **Immersive Medium**, while the other half uses 3D space. One story incorporates theatre (being a 180-degree screen in an immersive theatre playing a video) alongside 3D space. Our interview findings suggest that the immersive environment should inherit some of the similarities from the physical environment in order to make it more relatable for the user; meanwhile, the creator should also keep in mind that the immersive environment is not a replica of the physical environment: "Those experience that they have in the physical space you have to carry some of them over, but then if you simply just replicating the physical space, that's also... not a very exciting experience." [arch]. We introduced the dimension **Environment Type** as we found environments that were primarily either abstract in nature (e.g. swirling colours and floating platforms), recreations of real locations (e.g., using 360 videos) or fictional locations that could practically be real (e.g., situated on the back of a virtual boat).

#### Data representation

In an immersive data story, We identified data representations whenever numeric data was present, whether verbal, textual or graphical. Out of 40% of the stories with one or other type of **Data Representation** including textual, verbal or graphical, only one is diegetic (embedded in the narrative).

#### Narrative style

The dimensions **Linearity** and **Narrative Style** reveal that the majority of the immersive stories are linear and author-driven. In author-driven stories, the user does not have agency over the story progression, while in reader-driven stories, the user has more agency. We define four classes of **Purpose**, i.e. *educate*, which encompasses (*inform* and *explain* from Lee et al. [23]), *entertain*, *persuade*, and *comfort* based on the communication goals for data stories defined by Ojo and Heravi [28]. However, education and entertainment are the two most common purposes highlighted in the design space. Only 10% of the stories aim to persuade the user.

#### Narration

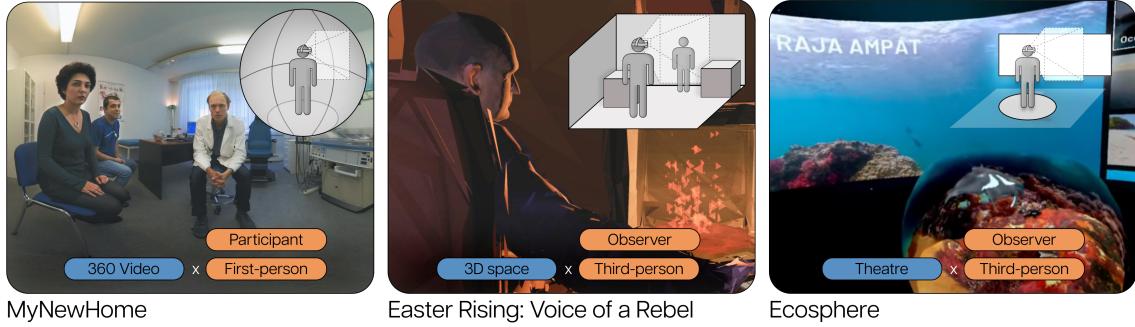
The interview findings highlight narration could be a crucial component of effective immersive data storytelling. Within the design space, various **Styles** of narration were identified, with the "Single Character" style, where a single character narrates their story to the audience, emerging as the most prevalent. Typically, narrations by a single character or through inter-character dialogue are triggered when the user is in close proximity to the object, while omniscient narrations are often used during introductions or to present the story's summary.

#### User point-of-view

A direct relation can be observed between **Camera Perspective** and **User's Role** with an exception of few stories. In the majority of cases, a first-person camera angle indicates that the user is a participant in the story (Figure 2), while a third-person camera angle suggests that the user is an observer (Figure 2).

#### Gamification

Four out of eight interviewees emphasised that gamification could be useful in immersive storytelling. We found three data stories with **Game Elements** where the user was given a certain goal to accomplish by interacting with the environment elements along with a reward at the end of the story. For instance, in the



**Figure 2: Three examples from immersive storytelling that inspired our design space: *MyNewHome* [34], *Easter Rising: Voice of a Rebel* [24], and *Ecosphere* [33].**

story "Breaking Boundaries in Science," the user must complete various tasks related to the notable works of female scientists to progress in the story. We believe that this approach allows users to explore all elements of the story while maintaining their curiosity and engagement.

#### User Interaction

The interviewees revealed that the interaction allows exploration, personalises the experience and supports decision-making. Therefore, the dimensions **Environment Interaction** and **Data Interaction** present that 42% of the stories have interactive elements in their environment, and only 10% out of 19 stories feature interactive data elements (Figure 2). For example, in the story "Overview," which takes the user on a journey through the universe, cosmic data is presented, allowing the user to interact with it by moving back and forth along the timeline to explore the information.

### 4.3 Discussion

**Immersive stories are primarily used to educate and entertain:** Our findings indicated that most immersive stories are used for education and entertainment. We speculate this is because of their ability to make learning interactive and engaging while entertainment enhances user involvement. Only 2 out of 19 immersive stories aimed to persuade, which is unexpected considering the perceived persuasive nature of VR [35], meriting further investigation.

**Single-character narration is primarily used:** The predominant use of single-character narration indicates a preference for a personalised storytelling approach when authoring immersive storytelling experiences. This style, often triggered by user proximity to objects, helps create a direct connection between the narrator and the user.

**Camera-perspective influences the User role:** There is a clear connection between the camera perspective and the user's role in the story. First-person perspectives generally position users as active participants, while third-person perspectives tend to cast them as observers.

**Connection between narrative linearity and story driver:** We observed that narrative linearity tends to influence the type of driver in immersive stories. Linear narratives tend to be author-driven, where the story progresses in a predetermined sequence without allowing the user to influence the outcome. In contrast, non-linear narratives often involve reader-driven elements, giving users

more agency to explore and interact with the story at their own pace. This relationship suggests that linearity directly influences how much control the user has over the narrative experience.

**Data representation is primarily non-diegetic:** Our findings reveal that non-diegetic data representations, those not integrated into the environment, are primarily used. This suggests a promising opportunity for further exploration, investigating whether embedding data representations within the narrative could enhance storytelling and user engagement.

**Data interaction is limited:** There are very few data stories (4 out of 19 stories) that have any sort of data interaction. This indicates a clear need for more work in this area, as interaction is a crucial aspect of immersive data stories that sets them apart from traditional stories.

**3D spaces primarily have data representations:** Our findings indicated that only 8 out of 19 immersive stories had data representations. We noticed the samples with representations tended to be within 3D space mediums. We speculate that specifically in immersive contexts, data representations may be better suited to 3D spaces, as opposed to 360 and theatre views. 3D spaces may be advantageous due to the user having more degrees of freedom (DOF) to navigate visual representations via (physically-driven pan and zooming) as prevalent in examples of Immersive Analytics [37, 41].

### 5 Conclusion and Future Scope

In this research paper, we explored immersive data storytelling. We attempted to curate a preliminary design space for creating immersive data stories informed by multi-disciplinary interviews and analysing the existing publicly available immersive stories. Through our investigation of the Meta Quest store, we derived several crucial observations. We found that immersive data stories (as we define them, containing aspects of immersion, data visualisation, and curated storytelling) are not prevalent in current practice. Among existing examples, 360 videos and 3D virtual environments are common, primarily representing real environments.

Using this information, we identified dimensions for a design space that can help support effective immersive data storytelling. With this design space, immersive content creators can begin to understand patterns for crafting engaging narratives that take advantage of the unique capabilities of immersive technology, such as VR, to engage and inform audiences with data stories.

Our work focused on primarily investigating data storytelling examples existing in Virtual Reality (VR); however, Augmented Reality (AR) [22] and other display modalities require further investigation. We envisage that our design space and expert perspectives can be used as a starting point to inspire further authorship and development of immersive data stories. In addition, this led to further research examining the different patterns established by our presented design space. As the landscape of immersive data stories evolves with the advent of more adoptable VR devices and authored data stories, we hope to revisit and expand our framework in the future.

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