

Telling Data Stories with the Hero's Journey: Design Guidance for Creating Data Videos

Zheng Wei , Huamin Qu, and Xian Xu

Abstract—Data videos increasingly becoming a popular data storytelling form represented by visual and audio integration. In recent years, more and more researchers have explored many narrative structures for effective and attractive data storytelling. Meanwhile, the Hero's Journey provides a classic narrative framework specific to the Hero's story that has been adopted by various mediums. There are continuous discussions about applying Hero's Journey to data stories. However, so far, little systematic and practical guidance on how to create a data video for a specific story type like the Hero's Journey, as well as how to manipulate its sound and visual designs simultaneously. To fulfill this gap, we first identified 48 data videos aligned with the Hero's Journey as the common storytelling from 109 high-quality data videos. Then, we examined how existing practices apply Hero's Journey for creating data videos. We coded the 48 data videos in terms of the narrative stages, sound design, and visual design according to the Hero's Journey structure. Based on our findings, we proposed a design space to provide practical guidance on the narrative, visual, and sound custom design for different narrative segments of the hero's journey (i.e., Departure, Initiation, Return) through data video creation. To validate our proposed design space, we conducted a user study where 20 participants were invited to design data videos with and without our design space guidance, which was evaluated by two experts. Results show that our design space provides useful and practical guidance for data storytellers effectively creating data videos with the Hero's Journey.

Index Terms—The Hero's Journey, Narrative Structure, Narrative Visualization, Data Visualization, Data Videos

1 INTRODUCTION

In the 1940s, mythologist and literary professor Joseph Campbell who was one of the greatest storytellers [17] introduced the concept of the monomyth, as well as called “the Hero’s Journey” [18], a traditional storytelling archetype and dramatic structure that has been widely applied across various narrative mediums including literature [32], theater [29], and cinema [55, 57]. This classical narrative theory plays a significant role in enhancing narrative efficiency for creators across these fields. Specifically, the Hero’s Journey outlines a series of storytelling stages beginning with the ‘Call to Adventure,’ where the hero accepts a challenge. This is followed by various ‘Trials’ or challenges and obstacles that the hero faces, culminating in the ‘Return,’ where the hero successfully comes back, often transformed and bearing significant changes. Within the visualization community, many researchers have been dedicated to exploring effective and efficient ways of storytelling and conveying accurate data insights through various perspectives [69], including exploring data visualization authoring tools [20], the design of animated visualization [64], affective visualization [43], cinematic data visualization [25, 78, 79], and 3D data videos [80]. Different types of data stories have unique storytelling requirements [39]. Our observation of high-quality data videos reveals that the Hero’s Journey is a common storytelling type of data videos. However, little is known about how to specifically design the narrative, visual, and sound tailored for particular types such as the Hero’s Journey of data videos. To address this gap, our work systematically investigates the Hero’s Journey within data stories, specifically within the increasingly popular format of data videos, examining how narrative, sound, and visual elements are designed and applied to the three core aspects (i.e., departure, initiation, and return) of the Hero’s Journey [18].

Specifically, this research faces three primary challenges. First, there

is a need for a precise definition and characterization of the Hero’s Journey-themed data videos, such as determining the proportion of high-quality data videos that fall under this narrative category to ascertain the significance of this classic narrative model in data video storytelling. Second, the Hero’s Journey is a conceptually distinct narrative type. There is still a critical challenge to clarify and comprehensively apply it to data videos. Therefore, a frequently raised doubt is how can traditional narrative theories be systematically applied to data stories [31, 46]. However, to our best knowledge, no work has been done to integrate the data storytelling needs of the Hero’s Journey into a more detailed and practical narrative framework. Third, we still lack a practical design space and clear guidance for implementing the Hero’s Journey story designs in data videos, such as what narrative stages can involve, where to apply the specific visual and sound design patterns in each narrative structure, and how to perform the design. Only by addressing these questions can we compile practical design space for narrating the Hero’s Journey through data videos and propose specific design strategies and techniques for designers.

To overcome these challenges, we first surveyed data videos, extracting 48 data videos related to the Hero’s Journey from 109 high-quality data videos. We defined the Hero’s Journey of data videos as *sequential stories using historical data to shed light on insights pertinent to current or future scenarios, succinctly tracing the subject’s journey through obstacles, achievements, and trials, with an emphasis on mentor or peer support and the acquisition of crucial insights and experiences*, and we illustrated two data video cases aligned with the Hero’s Journey in Sec. 3. To make our observations on narrative guidance more practical for data videos, we drew inspiration from a traditional existing screenwriting framework (i.e., *Screenwriting: The Sequence Approach* [34]) that helped us divide data videos into specific sequences with its unique function. Based on this framework, we coded 48 data videos for narrative, sound, and visual elements with the Hero’s Journey (Sec. 4). We then evaluated the usability and effectiveness of our design space and guidance through a workshop (Sec. 5) and reported our qualitative and quantitative results (Sec. 6). Last, we discussed our limitations and the lessons we learned about understanding the Hero’s Journey narrative implementation in data videos (Sec. 7).

2 BACKGROUND AND RELATED WORK

To motivate our research, we review the literature on narrative visualization and data storytelling and the Hero’s Journey for data video.

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Manuscript received xx xxx. 201x; accepted xx xxx. 201x. Date of Publication xx xxx. 201x; date of current version xx xxx. 201x. For information on obtaining reprints of this article, please send e-mail to: reprints@ieee.org. Digital Object Identifier: xx.xxxx/TVCG.201x.xxxxxxx

2.1 Narrative Visualization and Data-Driven Storytelling

Narrative visualization, as well as storytelling with data visualization, was first identified as seven genres by Segel and Heer [62] in 2010. During the past decades, data-driven storytelling has increasingly become a widely adopted strategy, leveraging data visualization to communicate data insights effectively and efficiently [31, 68]. In the early exploration of data storytelling, researchers explored effective and understandable storytelling methods for integrating complex visualizations into narratives [60]. Subsequently, researchers have further explored different design patterns genres for narrative visualization including in the narrative forms of data videos [1, 2], data comics [6, 75], data GIFs [65, 77], timeline visualization [14, 49], and dashboard [4, 36]. For instance, Bach et al. [5] have shown how data visualization can be combined with narratives to create compelling stories by identifying data-driven narrative design patterns such as annotations, time series, and comparison views. Furthermore, as data-driven storytelling research deepened, many researchers reflected and expanded the narrative visualization design space and guidelines as design guidance for data designers [41–45, 63, 64]. Such as research on semantic and emotional visualization animation design [45, 64, 67], the exploration on affective visualization [41, 43, 44, 76], the application of dramatic narrative theories in data-driven storytelling [63, 81], design guidelines for data videos derived from documentary and cinematic techniques [12, 48, 78, 79], and anthropographics [11, 53] are all attempts to improve the effectiveness and accuracy of data storytelling via various perspectives for common data stories. To the best of our knowledge, no work has systematically explored how to customize a specific data story type for data videos. Thus, our work attempts to customize the guidance for data videos of the Hero’s Journey.

2.2 The Hero’s Journey for Data Video Storytelling

The Hero’s Journey [18], a classic narrative framework, has proven its effectiveness across various storytelling mediums, including literature, film, and broader narrative endeavors [8, 15, 17]. Meanwhile, in the contemporary era driven by data, data videos emerge as a popular data storytelling format that effectively melds visual and sound to convey complex data insights [1]. Many researchers explored guidelines and design space for data storytelling [14, 21, 51, 66]. However, merely combining data visualization with narrative is not sufficient to guarantee the successful transmission of information. Within this transformation process, a meticulously crafted narrative structure plays a pivotal role, guiding viewers through the vast sea of data to capture the essence of the story [19]. When considering suitable narrative structures for data videos, Joseph Campbell’s model of the Hero’s Journey offers a compelling perspective. In the previous works, researchers attempt to apply traditional storytelling structures to data stories and data videos. For instance, Amini et al. [1] observed the narrative structure of data videos based on Aristotle’s *Three Act Play* [3] and Cohn’s *EIPR Structure* [23]. Subsequently, Yang et al. [81] provided a design space of Freytag’s *Pyramid Structure* [30] for data stories. The aforementioned work has greatly deepened the understanding of how to manipulate classic theory for data stories. However, to the best of our knowledge, the specific application and practical research on integrating the Hero’s Journey narrative framework into data video storytelling is still unexplored. Specifically, our work focuses on the Hero’s Journey design guidance for data videos rather than general data storytelling structures.

3 CASE ANALYSIS

We present case analysis from our corpus to illustrate how existing data videos aligned with the Hero’s Journey (see Fig.3) and to give a preview of how the concepts in our design space (i.e., *narrative stages*, ↗ *sound design*, ━ *visual design*) are presented in data videos.

3.1 Case 1: How Michigan explains American politics

Vox’s video, released on January 11, 2024, with 1.44 million views, analyzes the GOP’s dynamics in Michigan. **Departure**. Sequence 1 (Guided Discovery) narrates the consistency of Michigan with the

Democratic “Blue Wall” before 2016, as shown in Fig1 (1). ↗ *Emphasizes the dubbing, highlighting that Trump’s victory signifies a change in Michigan*. **Sequence 2 (Visualization Quest)** ━. Utilizes static bar charts to compare changes in various data segments, uncovering specific data and supportive narratives, as depicted in Fig1 (2). ↗ *Creates a distinct auditory experience that highlights Republican and Democratic electoral victories in Michigan, capturing audience attention*. It analyzes Republican governance in a Democrat-leaning state and its policy impacts on unions, abortion, and the environment. **Initiation**. **Sequence 3 (Trial by Data)**, as shown in Fig1 (3). ━. Employs bar charts to dissect data visualization for exploring and understanding different data layers. ↗ *The guitar’s rhythm changes reflect the exploration and challenges of analyzing historical election data shifts in Michigan*. This data tracks changes in demographic structures and voting patterns in major counties. **Sequence 4 (Alliance Formation)** ━. By continually adding data to the same graph, the chart illustrates the sudden surge in Trump’s support that foreshadowed his 2016 election victory.. ↗ *Primarily Enhances the role of voice-overs and sound effects, providing clear emphasis that the white working-class area of Macomb aligned with the national trend until a significant shift in 2016*. Many voters then switched their allegiance to Donald Trump during his campaign. **Sequence 5 (The Transformation)** ━. Uses a zooming out 2D map to highlight specific locations, capturing the impact of political changes in Michigan on the evolving voter population, especially the influence from suburban women in Oakland County. ↗ *The overall sound presents a progressive melody combined with harmonious sound effects*. **Sequence 6 (The Reward)** ━. Showcases a static bar chart in full screen, presenting the changes in Michigan’s voting situation from 2012 to 2022, see Fig1 (6). ↗ *Employs bright melodies, uplifting music, and voice-overs with a positive tone to emphasize the radical changes that took place in Michigan by 2022*. In the midterm elections, which were initially viewed favorably by Republicans, Democrats gained control of all branches of Michigan’s elected government—the governorship, the House, and the Senate. **Return**. **Sequence 7 (Mastery of Insights)** ━. Displays a bar chart showing the comprehensive victories of both parties after the establishment of the redistricting commission, see Fig1 (7). This made the map more equitable, with Democrats regaining control of the districts. This map adjustment ensured more balanced representation, reflecting the changing political landscape and voter preferences. ↗ *Features a steady and balanced rhythm*. **Sequence 8 (Embracing Data-Driven Culture)** ━. Start by zooming in on the bar chart to better reveal that Michigan’s election represents the national approval level, see Fig1 (8). These visualizations summarize Michigan’s political adjustments, portraying them as indicators of national trends, and predict changes in voter sentiment and party alliances that are shaping the political future. ↗ *Adopts a vibrant and free rhythm*.

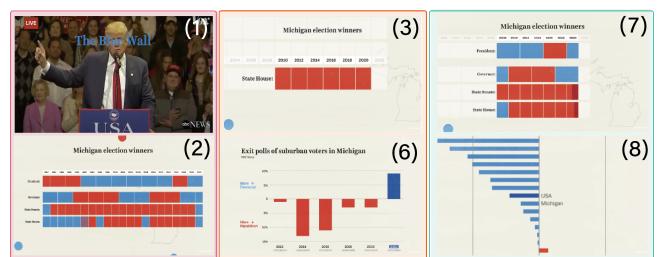


Fig. 1: Following the Hero’s Journey design space, case 1: How Michigan explains American politics, 18Minutes [73]: (1)-(2) corresponds to **Departure**; (3)-(6) to **Initiation**; and (7)-(8) to **Return**.

3.2 Case 2: How Sure Are Climate Scientists, Really?

Released on April 22, 2021, by Neil Halloran is an animated documentary that garnered 1.67 million views. **Departure**. Sequence 1 (Guided Discovery) ━. Shows Earth’s Ice Age state 20,000 years ago

with a 3D map marking today's cities, revealing climate changes over millennia, as shown in Fig 1 (1). This leads to a discussion on climate change. ↳ Introduces experts' warnings about climate change and the inherent uncertainties in scientific predictions by gradually lowering the music and enhancing the voice-overs with sound effects. Sequence 2 (Visualization Quest). ↳ Compares various data bars using a fixed set of bar graphs, explaining how certain scientific fields like geology and physics (hard sciences) provide a foundation for climate science, as shown in Fig 1 (2). The author uses the concepts of "hard" and "soft" sciences to emphasize how some scientific findings are difficult to replicate, thereby affecting people's trust in scientific conclusions. ↳ Opt to eliminate music, reduce sound effects, and enhance the voice-overs. **Initiation.** Sequence 3 (Encounter with the Shadow). The author delves into the specifics of climate science. ↳ Transitions from initially stirring music to gradually calming (with an emphasis on voice-overs and a reduction in sound effects and music) to discuss how Earth's orbit and other long-term cycles are linked to evidence of ice ages and current climate trends. Scientists use various types of evidence, such as ice cores and fossils, to estimate past temperatures and express uncertainties through error margins. ↳ The author examines temperature data trends from various research projects through line graphs, uncovering significant discrepancies in data from the same period due to multiple factors, as shown in Fig 1 (3). Sequence 4 (The Ultimate Test). ↳ Using line graphs to fully display several glacial periods in Earth's history, finding evidence of glacial periods only in green tags, while red tags have none. ↳ The emotional tone of the sound is noticeably higher than in the previous section. The author identifies a major challenge through the line graph: despite scientific clarity on Earth's history and climate change, ambiguities and distortions highlight the scientific process's challenges and limitations. Sequence 5 (The Revelation). ↳ Using a combination of imagination and careful examination to transform animations into model diagrams of Earth's climate, telling the audience that a change in traditional understanding of current climate change issues is needed. ↳ Using breakthrough sound effects to convey how hard sciences become "softer" when shifting from straightforward calculations to predicting human behavior and the impact of policies, as the latter are inherently less certain. Sequence 6 (The Transformation). ↳ The author uses gradually zooming-in line graphs to show predictions of future temperature increases by various countries, as shown in Fig 1 (6). ↳ A soothing and harmonious combination of sound effects is used to convey the message, "Although predictions of future temperature increases vary among different countries, the understanding of the global warming trend is certain." **Return.** Sequence 7 (Guided Acceptance). The author summarizes and reiterates the key points. ↳ Enhancing the voice-overs and reducing sound effect and music. ↳ Emphasizing the importance of understanding the uncertainties in climate science without being paralyzed by them, as shown in Fig 1 (7). Sequence 8 (Embracing Data-Driven Culture). ↳ The video transitions from temperature rising trend lines to 3D maps of different locations, vividly showing cities submerged due to rising sea levels, as shown in Fig 1 (8). Despite uncertainties, scientists have reached a clear consensus on the significant impact of human activities on climate change. ↳ This segment uses a free and light-hearted melody.

4 DESIGN SPACE

In this section, we present the methodology employed to formalize our design space and provide a detailed exposition of the design space.

4.1 Methodology

An iterative coding approach is adopted to analyze data videos with the Hero's Journey during data collection and corpus analysis. Two authors with film and visualization interdisciplinary research backgrounds participated in the coding process. One has four years of experience in narrative visualization and human-computer interaction research, as well as eight years of experience in screenwriting. The other has two

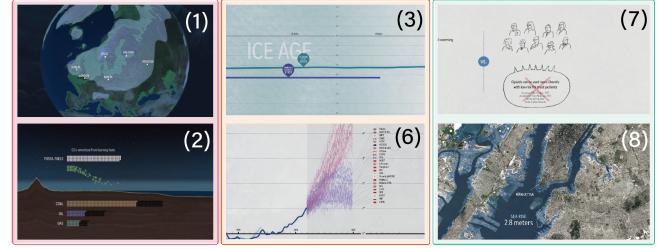


Fig. 2: Following the Hero's Journey design space, case 2: How Sure Are Climate Scientists, Really? 24 Minutes [9]: (1)-(2) corresponds to Departure; (3)-(6) to Initiation; and (7)-(8) to Return.

years of experience in visualization design and more than ten years of teaching experience in practical film production.

Data Video Selection. Our dataset was informed by existing research [78, 81] and included content from major news sources (such as Vox, The New York Times, and BBC) as well as well-known online platforms (including YouTube, Vimeo, and Tencent Video). We used search terms like "data story video," "data-driven narrative," and "data visualization video" on YouTube and other online video platforms, prioritizing videos with a high number of views to ensure our analysis covered the most impactful and representative data storytelling. Based on this, we collected 109 high-quality data videos. Then, we further identified the criteria for selecting data videos including (1) The video must be grounded in data analysis and presentation; (2) Each data video should include at least one form of data visualization, using charts or other visual aids to make the data easily understandable; (3) The narrative structure should conform to the Hero's Journey narrative framework; (4) The data video should include "Mentor," "Challenge," and "Lessons Learned" elements, emphasizing their role in the narrative. Two authors conducted independent coding of 109 data videos and held meetings for three rounds of discussion to reach a consensus of 48 data videos aligned with the Hero's Journey in total.

Data Video Analysis. We first separated each data video into three main segments: *Departure*, *Initiation*, and *Return* based on the Hero's Journey. Then, we described each narrative segment from three dimensions: *Narrative Stages*, ↳ *Sound Design*, and ↳ *Visual Design*. Inspired by previous work [6, 81], narrative pattern as well as the narrative stage serves as a significant component of the data stories design space. Specifically, while data videos is a visual and sound storytelling form, we conclude visual design and sound design to our design space.

For the narrative stages, further research has revealed that data videos following the Hero's Journey narrative align closely with the eight-sequence structure rule commonly used by screenwriters [34]. The eight-sequence structure decomposes the story into eight major sequences with independent themes and purposes to build the narrative, aiming to maintain both structural integrity and audience interest [16]. This observation inspired us to combine the narrative stages of the Hero's Journey and the screenwriter's eight-sequence structure rule to configure the design space, closely integrating the narrative stages of "the call to adventure," "trials and victories," and "return with the elixir." Furthermore, we referenced the widely used the Hero's Journey narrative type in movies [10, 71], and studies on the application of other narrative theories in data storytelling [63, 81].

↳ For the sound design, we consulted an expert and conducted a comprehensive review of research in movies, video games, and other media, focusing on how sound design can enhance storytelling, emotional expression, and audience immersion [22, 24, 27].

↳ For the visual design, we reviewed previous designs of movie narrative imagery [28] and design strategies for visual communication of the openings and endings of data videos [78, 79]. We conducted both open [33] and close [58] coding of the data. In the first phase, we conducted independent coding of 24 (50%) of our corpus using thematic analysis [13] to identify their *Narrative Stages*. Through the discussion of these codes among two authors over six sessions. We

defined 17 segments of the *Narrative Stages* (i.e., six in *Departure*, seven in *Initiation*, and four in *Return*) with the Hero's Journey in data videos. The first author completed the coding of the narrative stages on the remaining set. In the second phase, we sought to characterize the *Sound Design* and the *Visual Design* of the corpus. Two authors independently coded 10 (20%) data videos and refined the coding until they had reached agreements on sound and visual design aligned with each narrative stage. Then, two authors independently coded all the corpus of their *Sound Design* and *Visual design* for each narrative stage at least three rounds of discussion before reaching a consensus. In the third phase, after we finished the initial version of the design space, we conducted pilot studies (two authors with two experts) to validate our design space with two experts (one is a data visualization researcher and another is a film screenwriter) to ensure that they could understand our design space and provide some domain expertise. For example, the initial design space included uniform lateral movement, variable speed lateral movement, and variable speed curves to describe the camera's motion for capturing the visualization changes of chart data. However, we realized that these items are all low-level techniques, aimed at enhancing the audience's perception of the rate and rhythm of data changes. Therefore, we consolidated them into a method called "Presentation of the Target (Object)." Furthermore, we also renamed some items with the help of experts to increase the clarity and conciseness of our design space. In the final version of our design space, we provided teaching materials for each segment. All the detailed coding sheets and teaching materials can be found in our supplementary materials.

4.2 Design Space Overview

This section describes the definition and function of each dimension in our design space.

Dimension I: Narrative Stages. Understanding narrative patterns is crucial for writers and storytellers as it determines how information is organized and presented to effectively engage the audience [70]. By leveraging different narrative structures, creators can craft compelling stories that resonate with viewers [82]. The narrative patterns found in data stories can also be seen as analogous to the classic plots of literary narratives [62]. This is particularly true when creating "Exploration of History and Forward-Looking Insights" types of data videos, where the three stages of the Hero's Journey — Call to Adventure, Exploration, and Transformation — can be cleverly integrated. This narrative technique not only makes the data more lively and interesting but also aids the audience in building a deeper understanding of the information [43].

Dimension II: Sound Design. Sound design plays an indispensable role in enhancing the narrative experience of data videos. It involves the selection, processing, and integration of audio elements to support and elevate the narrative, highlight the emotional arc of the story, and create an immersive atmosphere, allowing the audience to engage on a deeper emotional level. Given the complexity of sound design, we consulted an expert with 4 years of experience in sound design of film industry for professional support on analyzing audio elements in videos. Following the expert's advice, we categorized sound design into three components: sound effects, music, and voice-over. Furthermore, aligning with the classification of sound components in movies [26], sound effects were further divided into ambient sound effects, action sound effects, and digital sound effects. Considering the Hero's Journey as a temporally sequential narrative structure, we employ a time (X-axis) - emotional intensity (Y-axis) coordinate system to describe the sound design of each narrative type. Emotion refers to the emotional amplitude conveyed by the sound [7,54], and time denotes the narrative's development duration. The coordinate system includes curves for sound effects, music, and voice-over. Our analysis of 48 data videos highlighted three main sound design strategies: thematic music for tone, sound effects for emphasis, and voice-overs to guide and engage the audience.

Dimension III: Visual Design. Our targeted selection of data videos that conform to the Hero's Journey narrative model, we have refined the visual asleveraging the Hero's Journey as a narrative framework in data videos, enhancing storytelling through the application of visual design techniques. Specifically, from 48 data videos that met our criteria, we analyzed and gathered a range of visual design methods, including

animation effects, camera movements, dynamic presentations of data charts, and video editing techniques. For example, one video segment used a line graph to demonstrate the historical trend of the data, with the camera continuously tracking these trend changes, allowing viewers to understand more clearly. These techniques collectively aim to elevate the visual presentation of data-driven storytelling, making the stories more engaging and easier to comprehend.

4.3 Departure

The *Departure* stage marks the beginning of the hero's journey. This stage sets up the forthcoming challenges. We have identified six narrative stages for the *Departure* as illustrated in Figure3, and we counted the frequency of each narrative stage's occurrence in 48 data videos.

Data Awakening (22/48). This stage marks the beginning of data awakening, where data is presented in its rawest form, providing the audience with an initial understanding that guides them through the unfolding narrative. ↗ It uses a time-emotional intensity coordinate system, mapping the relationship of sound effects, music, and voice-overs with emotional intensity on this system, showing how sound conveys emotion throughout the narrative, as illustrated in Figure3. Initially, background music and sound effects set a calm tone, with a low curve showing minimal emotional intensity. As the climax nears, the curve rises, indicating an upcoming twist. ↘ Animations transition between individual data points and an overview, highlighting trends and details to deepen story understanding.

Insight Trigger (19/48). This stage, the "Hero's Call to Adventure," reveals critical insights and anomalies that challenge norms and ignite curiosity, drawing audiences deeper into the data's implications. Enhanced sound design amplifies drama and emotional engagement, deepening data comprehension. ↗ Sound and music changes convey urgency, notably at pivotal discoveries, highlighting the exploration's significance. For example, in the data video "Teaching in the US vs. the rest of the world," [72] a specific sound effect is used when questioning how to prevent American teachers from leaving their jobs. This is followed by an increase in music volume to underline the significance of exploring the reasons behind this issue. ↘ The design adopts a simulated camera's first-person perspective, continuously tracking changes in data as if letting viewers personally experience moments of insight and discovery, deepening understanding of the story and inspiring further exploration.

Resistance to Change (8/48). This stage highlights the impact of skepticism and obstacles on embracing new insights, illustrating turning points and internal conflicts that stimulate viewer reflection. ↗ Sound design alterations, including effects, music, and voice-overs, signal resistance and doubt towards insights. ↘ Animations showcasing subtle data changes emphasize the uncertainty and dynamism of change.

Guided Discovery (22/48). This stage enriches data interpretation through new analytical tools, methodologies, or expert insights, aiming to uncover new understandings and solutions. ↗ Reflects this through changes in the emotional intensity of sound effects, music, and voice-overs. For example, it lowers the emotional intensity of sound effects and music while enhancing that of voice-overs during expert insights to guide discovery. ↘ It fully displays target, using animations, icons, and charts to intuitively present new tools, methods, or insights, helping the audience understand how these elements contribute to problem-solving. Case detailed refers to Sec. 3.2.

Commitment to Insight (6/48). This stage highlights the critical moment of "crossing the threshold," marking the transition from understanding to implementation. ↗ Heightens the intensity of sounds, music, and voice-overs at this moment, indicating a reinforcement of resolve to act and to stimulate anticipation. ↘ Integrates existing charts with new information to create entirely new visualizations. This results in detailed and rich presentations that intuitively show data changes and deepen the understanding of the importance of actions based on insights, enhancing the story's appeal and audience engagement.

Visualization Quest (19/48). This stage focuses on using data visualization and analysis to tackle challenges, seeking allies in corrobor-

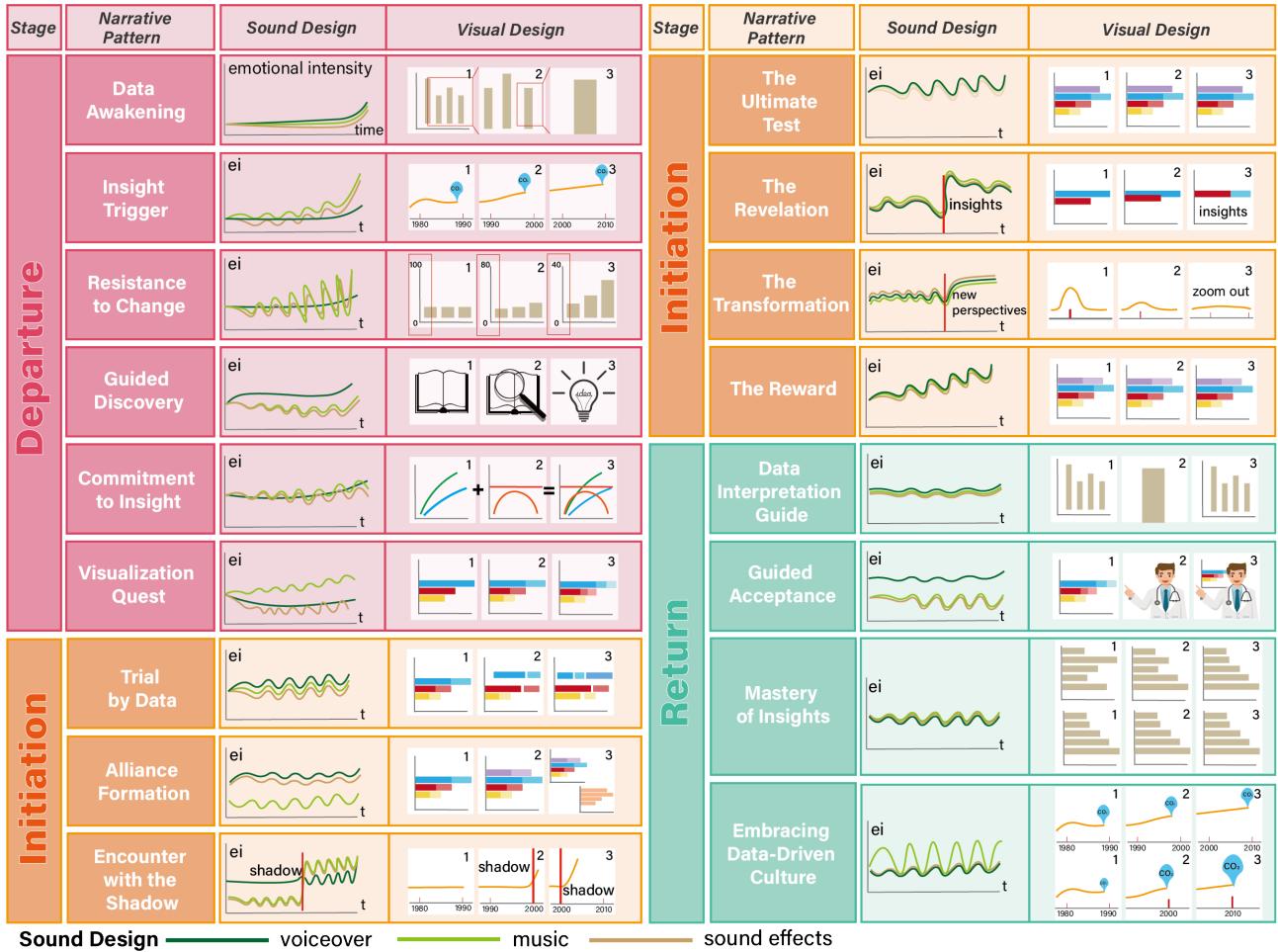


Fig. 3: Applying the Hero’s Journey as a framework for creating data videos, we organize a design space into three segments (i.e., **Departure**, **Initiation**, and **Return**), grounded in the narrative structure of the Hero’s Journey. The **Departure** has six narrative stages, the **Initiation** has seven narrative stages, and the **Return** has four narrative stages. Each narrative stage is equipped with corresponding sound design and visual design.

orating data or supportive narratives. ↗ Emphasizes one type of sound effects, music, or voice-overs—while reducing the others. For instance, it might enhance voice-overs to explain data contexts or amplify sound effects to highlight settings, creating a unique auditory experience that enhances story appeal. ↘ It employs static data charts with comparative data changes, directing viewers’ attention to specific charts, aiding in a clear understanding of the underlying story and trends. See Sec. 3.2.

4.4 Initiation

During the *Initiation* stage, the hero encounters trials and tests in an unfamiliar environment, leading to significant personal growth or new skills. We identified seven narrative stages and counted the frequency of each narrative stage’s occurrence in 48 data videos.

Trial by Data (35/48). This stage, Confronting the Abyss, represents deep exploration of complex data, handling contradictions, and iterative enhancement of data quality, each step deepening the understanding of the intricate data landscape. ↗ Reflects the exploration and challenges in dealing with data problems through changes and repetitions in sound effects, music, and voice-overs. For instance, variations in pitch, rhythm, or timbre symbolize the resolution of data quality issues or deeper understanding of information. ↘ Data visualizations are segmented to explore and understand different aspects of the data. Dividing data charts into finer segments allows audiences to delve deeper into and comprehend the data, with each subdivision representing a more profound understanding of the information. Details see Sec. 3.1.

Alliance Formation (30/48). This stage emphasizes using additional resources to enhance and enrich analysis when facing challenges.

↗ It primarily strengthens the role of voice-overs and sound effects, providing clear vocal guidance and cues to help audiences understand auxiliary datasets, tools, or analytical methods featured in the story. Visually, it employs strategies for expanded data presentation to deepen understanding of data alliances. ↘ By visually extending the range of data presentation, including visual comparisons of multiple datasets and analytical methods, it clearly demonstrates how each component supports and complements the others, thereby collectively constructing a more comprehensive and robust analytical framework. See Sec. 3.1.

Encounter with the Shadow (31/48). This stage typically involves encounter with the shadow that questions previous assumptions or beliefs, such as revealing a surprising and generally unwelcome insight.

↗ Primarily uses changes and contrasts in sound effects (including ambient sound effects and digital sound effects) and music to illustrate the emotional contrast before and after key challenges and unexpected insights. Deep bass or sudden changes in pitch effectively convey the tension and conflict faced with challenges, immersing viewers in the “shadows” of the data analysis process. ↘ It simulates the viewer’s perspective to track data trends, allowing viewers to explore data through the analyst’s view and follow the development of data trends until those challenging discoveries are made. See Sec. 3.2.

The Ultimate Test (30/48). This stage distills core challenges and revelations from the entire data story, summarizing findings and providing deep insights into the narrative. ↗ Using a mix of music, sound effects, and voice-overs, or just music or voice-overs alone, effectively highlights key findings and insights in data stories. At its emotional

peak, it uses tense, exhilarating, or revelatory sound design, including ambient and digital effects, to maintain high emotional intensity. **▀** Data charts or animations are generally presented in a panoramic format to ensure that the audience receives the most intuitive and comprehensive information display. The goal is to fully highlight the data story's core content. **Details see Sec. 3.2.**

The Revelation (25/48). This stage marks a climax in the data journey, revealing unexpected insights that challenge old views and guide new decisions. **⌚** Expressing the moment of breakthrough through changes in sound effects (including ambient, action, and digital sound effects), music, and voice-overs. **▀** This is represented through animation transitions where one scene or data chart morphs into another, showcasing new insights. **Details see Sec. 3.2.**

The Transformation (15/48). This stage, the transformation, illustrates how integrated insights offer fresh perspectives and inspire innovative ways to approach and understand issues. **⌚** The evolution of sound is depicted through smooth curves, progressive melodies, changes in rhythm, and a combination of harmonious effects, showcasing how sound evolves with the integration of insights and shifts in understanding. **▀** The expressiveness of these changes is enhanced by simulating the zoom function of a camera. The visual design alternates between zooming in on data details and zooming out for an overall view, not only showing the process from detailed analysis to holistic understanding but also emphasizing how new insights alter our overall perception of the data story. **Details see Sec. 3.1.**

The Reward (26/48). This stage, the “Climactic Revelation,” typically highlights actionable conclusions, decision-making guidance, or strategic insights distilled from the entire analysis process in data videos. **⌚** Curve generally shows an upward trend. By using rewarding sound elements and sound effects, the climax and key takeaways of the data story are cleverly presented, such as bright melodies, inspiring music, or voice-overs with a positive emotional tone. **▀** A method of fixed chart presentation is adopted to show the outcomes of the data story clearly. This design strategy highlights key data charts to underscore core conclusions and insights, aiding the audience in grasping important information. **Details see Sec. 3.1.**

4.5 Return

The hero returns transformed, having overcome a final test, and brings valuable insights or benefits back to their original world. In the *Return*, we identified four narrative patterns and counted the frequency of each narrative stage's occurrence in 48 data videos.

Data Interpretation Guide (26/48). This stage engages audiences in the profound insights gained from data analysis. **⌚** Features voice-overs, sound effects, and music in a soft and soothing style that reflects the discovery and assimilation of insights. The overall sound curve is smooth and tranquil, making viewers feel as though they are experiencing a magical journey of data exploration. **▀** Visual design adopts a “whole-part-whole” approach to display data, showcasing the relationship and flow between the overall and specific parts of data, enabling an appreciation of insights brought about by changes in the data.

Guided Acceptance (25/48). This stage uses external support, evidence, and expert validation to promote acceptance of insights and enhance the credibility of data stories. **⌚** Curve shows a decrease in the fluctuation of sound effects and music, with the emotional curve of voice-overs sitting above that of sounds and music. Sounds and music adopt a gradual rhythm, increasing the presence of elements that express steadfast support. Voice-overs introduce expert testimonials and success stories to reduce audience skepticism and build trust. **▀** Animations combine data charts with supporting videos to effectively display hard data and real-life cases, enhancing credibility and making the data story more compelling and persuasive. **Details see Sec. 3.2.**

Mastery of Insights (32/48). This stage demonstrates how data analysis can effectively support decision-making and strategy formulation in the real world. **⌚** The sound effects, music, and voice-overs all choose a stable and balanced rhythm, symbolizing the harmony

between insights and practical application. **▀** There are two methods to emphasize this balance. The first is “reorganizing data for observation,” which makes complex information easy to understand and observe by rearranging and structuring data. The second is “displaying the complete picture of data,” ensuring that the audience can see all relevant information and understand how data comprehensively affects the decision-making process. **Details see Sec. 3.1.**

Embracing Data-Driven Culture (18/48). This stage emphasizes the importance of fostering a culture that values data-driven decision-making, empowering individuals to explore and apply data confidently. **⌚**, the music’s amplitude is noticeably high, carrying more emotion than both the voice-overs and sound effects. The music typically features a vibrant and liberated rhythm, reflecting the spirit of embracing a data-driven culture. **▀** There are two approaches. The first is “marking and following data trends,” which uses animation to demonstrate how to identify, mark, and track key trends within data, aiding the audience’s understanding of the role of data analysis in uncovering and exploiting these trends. The second approach is “zooming in and out on data trends,” enabling viewers to comprehend the impact and significance of data trends from various perspectives. This method helps convey a multi-faceted view of how data informs decisions, highlighting its dynamic and interconnected nature. **Details see Sec. 3.1.**

Correlation between Dimensions We observed the correlation between dimensions of the Hero’s Journey in 48 data videos, identifying key stages in a compelling narrative arc, as shown in Figure 4.

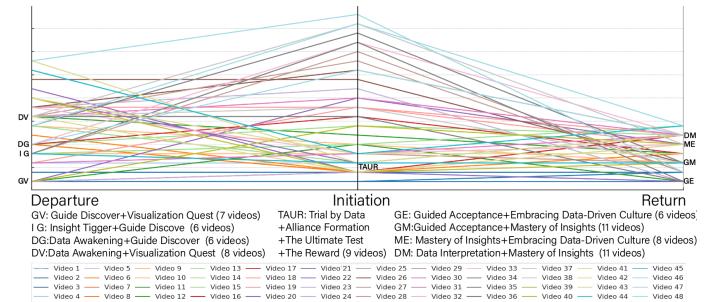


Fig. 4: The narrative stages of 48 data videos according to the dimensions of **Departure**, **Initiation**, and **Return**. Specifically, the most common pattern in **Departure** is “DA” + “VE” (8 videos) to foster engagement and exploration. The most common pattern in **Initiation** is “DJ” + “AF” + “UT” + “Re” (9 videos)

, reflecting transformative challenges. The most common sequence in **Return** is “GA” + “IM”, “DID” + “IM” (11 videos each), emphasizing the mastery and acceptance of insights.

5 WORKSHOP OVERVIEW

We conducted a workshop to investigate: 1) the usefulness of the design space, 2) the ease of use of the design space, and 3) how participants utilized the design patterns within our design space.

5.1 Participants

Through advertisements on online social media platforms, we successfully recruited 20 participants (9 F / 11 M), with ages ranging from 21 to 40 years ($\bar{M} = 26.5$, $SD = 3.0$). The group comprised university students, researchers, and professionals with backgrounds in design, art, computer science and data visualization. Furthermore, all participants have good vision or have had it corrected. The participants voluntarily participated, and the experimental scheme was approved by the university’s institutional review board. Before the workshop, only 3 participants were familiar with the Hero’s Journey narrative theory.

5.2 Workshop Materials

During the workshop, we provided participants with detailed materials introducing the design space, which thoroughly explained various narrative modes including specifics on content, data types, and video case

studies. These materials also guided designers on how to employ these narrative patterns effectively in sound and visual design to enhance their storytelling capabilities. We provided participants with two datasets for storytelling: SpaceX’s history and China’s economic growth since its founding. In alignment with recommendations from prior studies [1,6], our methodology extended beyond merely providing participants with raw data. We furnished them with a suite of pre-analyzed data metrics, including significant trends, percentile ranks, and frequency distributions, along with their respective visualizations [74].

5.3 Experimental Procedures

The workshop was held offline, divided into three parts, totaling 2 hours and 40 minutes. Due to time constraints, we modified the traditional data video production process to combine drawing storyboards with sound design, creating photo montage (edit) videos. Each storyboard was required to have 8 frames to depict the story. We provided datasets that included 3 complete background music tracks and 2000 sound effects (including ambient sound effects, action sound effects, and digital sound effects). All participants could use our sound materials or search for their own online. For voice-overs, we offered AI-assisted voice-over support, with scripts written by the participants themselves.

Part I (10 minutes). We introduced participants to data visualization, the Hero’s Journey narrative structure, data videos, storyboards, and editing software for making data videos.

Part II (30 minutes). The participants were randomly divided into two groups, with 10 people in each group. Both groups of participants were asked to use either of the provided datasets to design a data video based on the hero’s journey, with design space group members use the “Hero’s Journey Design Space” teaching materials, while without design space group members use the “Hero’s Journey Narrative Theory” teaching materials. The teaching materials for the Hero’s Journey Narrative Theory do not contain any audio or visual design guidance and consist only of an introduction to the Hero’s Journey narrative theory and structure. All participants had 20 minutes to conceptualize their data story, followed by a 10-minute demo on illustrating storyboard content and using audio for sound design in the editing software.

Part III (2 hours). The participants were asked to finish storyboard illustrations, sound design, and montage video production within two hours and they could ask organizers questions at any time. For participants with the design space group, the narrative stage for each segment can be chosen randomly, but it must follow a logic that progresses from top to bottom (as events unfold). Participants not in the design space group were not subject to this requirement. As depicted in Figure5, a participant utilizes the SpaceX dataset within a design space to create a data-driven narrative of a Hero’s Journey. All related storyboards and data videos are provided in the supplementary material.

After the workshop, participants completed a questionnaire on the design space’s usefulness and ease of use, rated on a 7-point Likert scale. All participants were also interviewed in a semi-structured format to gather their views on the entire workshop experience, with a special focus on the practical application of the Hero’s Journey narrative structure in creating data videos, the challenges encountered, and how our design space aided them. Some interviews were conducted via online meetings after the workshop. Interview questions focused on three aspects: (1) participants’ views on the process of using the Hero’s Journey narrative structure for making data videos; (2) the difficulties faced by (with)out design space assistance in drafting story outlines; and (3) how our design space helped with design space group improve their story creation. Each interview lasted about 5-15 minutes and was recorded for further analysis. To investigate how participants utilized our provided design space, two authors independently coded the story outlines and storyboards submitted by participants, especially analyzing the differences in narrative patterns, sound design, and visual design between participants who used the design space and those who did not. Based on these coding results, we calculated the usage frequency of various elements in our design space, i.e., the number of times each type of element was used by different groups.

We invited 2 industry experts to score the participants’ work. Expert 1 was from the film industry and expert 2 came from the short

video production company, each with more than three years of industry experience. We established scoring criteria, and two experts blindly evaluated all participants’ works. After consulting with two experts, we evaluated the work based on four key dimensions: Narrative Quality, Creative Expression, Emotional Transmission, and Visualization Design. These were selected for their comprehensive assessment of storytelling, creativity, emotional impact, and clarity of visual information. The ratings in the questionnaire ranged from 1 (Min) to 7 (Max). We summed and averaged the scores for the four dimensions.

6 RESULTS

This section presents the results of our workshop and expert reviews.

6.1 Design Space Usefulness

We analyzing differences between two groups using the Mann-Whitney U Test [50]. Figure6 depicts the results across three dimensions—Departure, Initiation, and Return—under two conditions, with four questions per dimension, totaling twelve questions. **Dimension 1 - Departure.**

As for the sub-question (Q1) ‘*I can understand departure section by these teaching materials*’, both groups, with ($\bar{M} = 4.9$, SD = 1.29) and without a design space ($\bar{M} = 4.9$, SD = 1.45), understood the materials equally, showing no significant difference ($U = 44.5$, p >0.05). Sub-question (Q2) ‘*Departure section aids narrative design for data videos*’ showed significant differences ($U = 78.0$, p <0.05): Design space users rated it more helpful ($\bar{M} = 5.4$, SD = 0.97) than non-users ($M = 3.8$, SD = 1.69). Sub-question (Q3) ‘*Departure section aids sound design for data videos*’ showed significant differences ($U = 83.0$, p <0.05): Participants with design space access rated it more helpful ($\bar{M} = 5.8$, SD = 0.92) than those without ($\bar{M} = 4.1$, SD = 1.60). Sub-question (Q4) ‘*I’ve found that departure section helps me with visual design for data videos*’ showed a significant difference ($U = 90.5$, p <0.01) between groups. Participants with design space access found it more helpful for visual design ($\bar{M} = 5.6$, SD = 0.84) than those without ($\bar{M} = 3.6$, SD = 1.43). **Dimension 2 - Initiation.**

Sub-question (Q1) ‘*I can understand the initiation section by these teaching materials*’ revealed no significant difference between groups ($U = 70.0$, p >0.05), with both design space users ($\bar{M} = 5.6$, SD = 0.84) and non-users ($\bar{M} = 4.5$, SD = 1.58) understanding the materials equally. Sub-question (Q2) ‘*I’ve found that initiation section helps me with narrative design for data videos*’ reflects an obvious difference ($U = 79.0$, p <0.05) among two conditions: with a design space ($\bar{M} = 5.7$, SD = 1.06) and without ($\bar{M} = 4.0$, SD = 1.76). Sub-question (Q3) ‘*Initiation section aids sound design for data videos*’ showed a significant difference ($U = 91.5$, p <0.01) between groups. Participants with initiation design space access ($\bar{M} = 5.5$, SD = 0.97) rated it more effective for sound design than those without ($\bar{M} = 2.8$, SD = 1.55). Sub-question (Q4) ‘*Initiation section aids visual design for data videos*’ showed a significant difference ($U = 92.0$, p <0.01) between groups. Participants using the initiation design space ($\bar{M} = 5.8$, SD = 0.92) found it significantly more effective for visual design than those without ($\bar{M} = 3.6$, SD = 1.43). **Dimension 3 - Return.**

Sub-question (Q1) ‘*I can understand return section by these teaching materials*’ both groups, with ($M = 5.4$, SD = 1.17) and without a design space ($\bar{M} = 4.8$, SD = 1.81), understood the materials equally, showing no significant difference ($U = 58.0$, p >0.05). Sub-question (Q2) ‘*I’ve found that return section helps me with narrative design for data videos*’ showed significant differences ($U = 83.0$, p <0.05). Participants with a design space ($\bar{M} = 5.3$, SD = 1.06) performed better in narrative design than those without ($\bar{M} = 3.2$, SD = 1.81). Sub-question (Q3) ‘*Return section aids sound design for data videos*’ demonstrated significant differences ($U = 89.0$, p <0.01). Participants without a design space rated the return section less helpful for sound design ($\bar{M} = 3.1$, SD = 1.66) compared to those with a design space ($\bar{M} = 5.6$, SD = 1.07). Sub-question (Q4) ‘*Return section aids visual design for data videos*’ revealed a significant difference ($U = 92.5$, p <0.01). Participants with a design space found it more supportive for visual design ($\bar{M} = 5.6$, SD = 0.84) compared to those without ($\bar{M} = 3.1$, SD = 1.29).

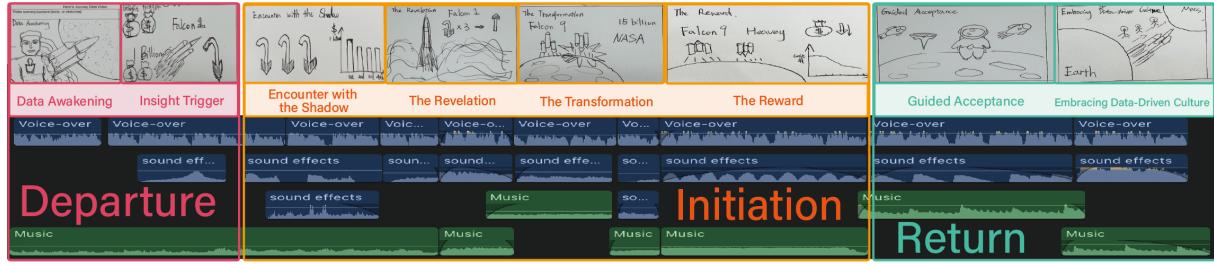


Fig. 5: This figure is an example of a storyboard created by a participant using a guide. Utilizing the historical dataset of SpaceX, the participant crafted a data story of a Hero's Journey. From top to bottom, the sections are the storyboard visuals, the guide used for explanation, and the sound design displayed according to voice-over, sound effects, and music.

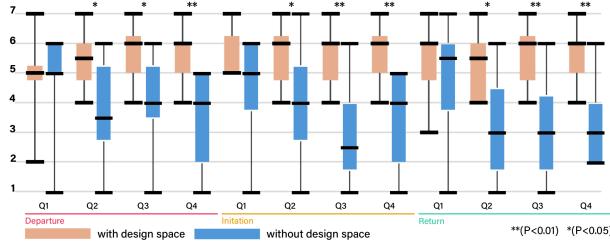


Fig. 6: The participants rated the “Design space usefulness” in terms of *Departure*, *Initiation*, and *Return*, with scores ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

6.2 Easy to Use Design Space

Figure 7 depicts the results across three dimensions—Departure, Initiation, and Return—under two conditions, with three questions per dimension, totaling nine questions. **Dimension 1 - Departure.** Sub-question (Q1) ‘I think the narrative guidance for the departure section provided in the instructional materials is easy to use’ showed a significant difference ($U = 83.5$, $p < 0.05$). Participants rated materials with a design space as easier for narrative design ($\bar{M} = 5.1$, $SD = 1.20$) compared to those without ($\bar{M} = 3.3$, $SD = 1.42$). Sub-question (Q2) ‘I found the sound design of the departure section easy to use’ indicated a significant difference between groups ($U = 86.0$, $p < 0.01$). Participants found materials with a design space ($\bar{M} = 4.9$, $SD = 1.45$) easier for sound design compared to those without ($\bar{M} = 3.0$, $SD = 0.94$). Sub-question (Q3) ‘I found the visual design of the departure section easy to use’ reflects an obvious difference, ($U = 92.5$, $p < 0.01$). Participants with a design space ($\bar{M} = 5.6$, $SD = 1.17$) found visual design in data videos easier than those without ($\bar{M} = 3.0$, $SD = 1.41$). **Dimension 2 - Initiation.** Sub-question (Q1) ‘I think the narrative guidance for the initiation section provided in the instructional materials is easy to use’ revealed a significant difference ($U = 89.0$, $p < 0.01$). Participants rated instructional materials with a design space ($\bar{M} = 5.7$, $SD = 0.95$) as easier for narrative design than those without ($\bar{M} = 3.7$, $SD = 1.42$). Sub-question (Q2) ‘I found the sound design of the initiation section easy to use’ showed a significant gap between groups ($U = 92.5$, $p < 0.01$). Participants using instructional materials with a design space found it easier to create data videos ($\bar{M} = 5.6$, $SD = 1.26$) compared to those without a design space ($\bar{M} = 3.1$, $SD = 1.10$). Sub-question (Q3) ‘I found the visual design of the initiation section easy to use’ demonstrated a significant difference ($U = 86.5$, $p < 0.01$). Participants found the visual design easier with a design space ($\bar{M} = 5.3$, $SD = 1.16$) compared to without ($\bar{M} = 3.4$, $SD = 1.35$). **Dimension 3 - Return.** Sub-question (Q1) ‘I think the narrative guidance for the return section provided in the instructional materials is easy to use’ showed significant differences ($U = 83.5$, $p < 0.05$). Participants using materials with a design space found narrative design easier ($\bar{M} = 5.6$, $SD = 0.84$) compared to those without ($\bar{M} = 3.6$, $SD = 1.71$). Sub-question (Q2) ‘I found the sound design of the return section easy to use’ demonstrated a significant difference ($U = 88.5$, $p < 0.01$). Participants with a design

space found it easier ($\bar{M} = 5.5$, $SD = 0.97$) compared to those without ($\bar{M} = 2.8$, $SD = 1.81$). Sub-question (Q3) ‘I found the visual design of the initiation section easy to use’ showed a significant difference ($U = 89.5$, $p < 0.01$). Participants using a design space reported easier visual design ($\bar{M} = 5.7$, $SD = 0.82$) compared to those without ($\bar{M} = 3.3$, $SD = 1.63$).

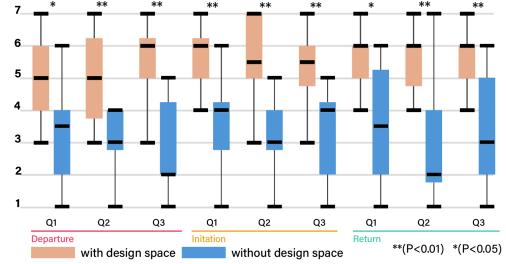


Fig. 7: Participants rated the “Easy to use design space” in terms of “Departure,” “Initiation,” and “Return,” with scores ranging from 1 (Strongly Disagree) to 7 (Strongly Agree).

6.3 Design Space Usage

Participants using the design space created different data stories based on the two datasets. For instance, the six stories about SpaceX covered various angles, including the dawn of the commercial space age, young people growing with the company, SpaceX’s journey from dream to reality, and its impact on human aviation history. Every narrative mode provided was used, with sound and visual design being widely adopted (sound design 14/17, visual design 20/21). Particularly, sound design was highly praised. As stated by Participant 8 of the design space group: “Initially, I thought sound effects were an insignificant element, but after designing with them, I realized that good sound design is crucial and can significantly enhance the effect.” The participants 1, 2, 3, 5, 6, 8, and 10 from the design space group found that the sound design options provided effectively aided the narrative and enhanced emotional resonance with the data videos. Additionally, the participants 1, 2, 3, 4, and 9 from the design space group stated that the visual design guidelines provided made it easier for them to design data charts, as Participant 1 from the design space group said, “These guidelines made the design of data visualization charts easier for me, without the burden of too much thought.” However, for Participant 5 in the without design space group, creating a hero’s journey data story through the materials presented a challenge: “I spent 40% of my time trying to establish a relationship between the narrative theory of the hero’s journey and the material data set. I found this very difficult, whether in terms of narrative or the way the data (animation) was presented.” Participants 1, 2, 3, and 8 in the without design space group also expressed facing similar challenges during the creation process. Analyzing the narrative types used by 10 participants in the with design space group revealed interesting patterns: Encounter with the Shadow was the most common in sound design (7/10) and also prevalent in initiation narratives. The participants favored starting with data awakening (6/10) and concluding

with Embracing Data-Driven Culture (6/10). For example, in the stories about SpaceX, two data stories concluded with a combination of sound and visual design integrated into chart design. One used a camera tracking a rocket's journey from Earth to Mars, simulating a line chart effect. As the rocket sound fades, it conveyed the vision of humanity landing on Mars in the future. Another represented human exploration of space with bubbles, accompanied by a series of bubble sounds, with the camera following the bubbles' drift, subtly marking another milestone in aerospace history pushed by SpaceX. This demonstrates that our design space, integrating sound and visual elements, fosters creativity and flexible, emotionally rich data narration.

6.4 Expert Reviews

After the workshop concluded, we evaluated the data stories created by the 20 participants. The results, scored by the two experts, showed that participants using instructional materials with a design space ($\bar{M}=4.9$, $SD=0.92$) produced Hero's Journey data stories of significantly higher quality than those using materials without a design space ($\bar{M}=3.2$, $SD=0.96$). As illustrated in Figure 8, a one-way ANOVA ($F_{1,18} = 16.95$, $p < 0.001$) indicates that the Hero's Journey design space slightly outperforms traditional narrative theories of the Hero's Journey in creating Hero's Journey data stories.

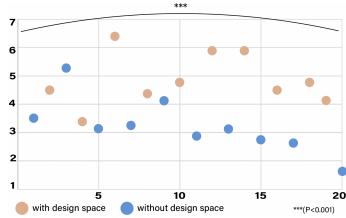


Fig. 8: The Hero's Journey data stories rated by two experts, showing the average of the combined scores from four categories. X-axis: Participant IDs, and Y-axis: score.

The scoring for each component is as follows: in the narrative aspect, with design space group ($\bar{M} = 5.6$, $SD = 1.01$), compared to without ($\bar{M} = 4.2$, $SD = 0.95$). In the creative expression aspect, with design space group ($\bar{M} = 4.5$, $SD = 1.30$), compared to without ($\bar{M} = 3.1$, $SD = 0.94$). In terms of emotional transmission, with design space group ($\bar{M} = 4.2$, $SD = 1.36$), compared to without ($M = 2.6$, $SD = 0.97$). For visualization design, aspect with design space group ($\bar{M} = 5.3$, $SD = 1.12$), compared to without ($\bar{M} = 3.0$, $SD = 1.18$). Significant statistical differences were noted in all four dimensions.

7 DISCUSSION

In this section, we discuss the limitations of our work and the lessons learned to improve the storytelling of video data.

Enhancing understanding of the Hero's Journey in data video storytelling. Our analysis of 48 data videos reveals that the Hero's Journey pattern, typically divided into three distinct phases, is particularly effective for linear narratives involving time-series data. This narrative structure not only enhances viewer comprehension and engagement by providing a structured and progressive exploration of the data but also demonstrates its adaptability to other models like Freytag's Pyramid. For instance, the 'Departure' phase in the Hero's Journey aligns with the 'Exposition' in Freytag's model, focusing on laying the narrative groundwork by introducing the raw data, a stage we term 'Data Awakening.' This foundational stage sets the narrative progression and parallels the 'Introducing Backgrounds' [81] and 'Old Footage' [79] techniques in their cinematic and narrative frameworks. Despite these similarities, Hero's Journey requires a tight integration of its phases, each crucial to the completeness of the narrative, highlighting its unique demand for a cohesive and interdependent structure.

Making guidance accessible for creating data videos. When employing the Hero's Journey framework, one of the biggest challenges is ensuring that sound and visual design guidelines are understandable and actionable. To bridge this gap, we adopted a strategy of visualizing

the guidance, making it intuitive and accessible through a design space for data video designers and storytellers. Visualization is a cornerstone for effective storytelling by transforming abstract principles into concrete visual forms [46]. Our initiatives include creating intuitive chart animations and sound visualizations that combine narration [35], music, and sound effects, outlining each guideline within the Hero's Journey framework. These visual charts serve as a navigational tool and guide storytellers through the complex process of narrative creation. Furthermore, incorporating stage-specific design guidelines and clear story frameworks into authoring tools could make advanced narrative guidance more accessible [20, 47]. Future work we can broaden the accessibility and applicability of our guidelines, ensuring creators can effectively use our design space to tell compelling stories, even for structurally complex data narratives via authoring tools. Specifically, our findings illuminate potential synergies with existing data story authoring tools, particularly those focused on scrollytelling [38, 52, 66]. Our user study identified common narrative combinations that can enhance scrollytelling for data-driven Hero's Journeys, potentially helping storytellers convey complex data insights more effectively in the future.

Towards a preliminary exploration of sound design in data videos. Inspired by cinematic sound design [40, 56], our research for the first time to preliminary explore the role of sound in data storytelling, focusing mainly on music, voice-overs, and sound effects. We found that users guided by our manual often attempted to incorporate three types of sound effects (i.e., ambient, action, and digital) into their data videos, albeit imperfectly. In contrast, users with guidance rarely explored beyond ambient sounds, like rocket launches or crowd cheers, mainly sticking to music and voice-overs. Our user study shows that clear guidance can significantly enhance the depth and nuance of sound design in data storytelling. However, the interaction and mutual influence among sound effects, music, and voice-overs, as well as how they collectively affect the narrative structure and emotional engagement in data videos, have not been deeply studied [59, 61]. Analyzing the integration of sound within data videos reveals its ability to enhance narrative coherence, emphasize the importance of data, and adjust audience engagement. This aligns with previous studies that discuss the role of sound in film narratives [22]. Future work will investigate how various sound types shape data video narratives, focusing on their collective impact on narrative coherence and viewer engagement.

Balancing the generalizability and customization of data storytelling with the Hero's Journey. Our design space merges the Hero's Journey with the screenwriter's eight-sequence rule [34], tailored for those looking to enrich their data videos with impactful sound and visual effects. Therefore, on one hand, from the perspective of generalizability, it is particularly suitable for data videos of the Hero's Journey aimed at deepening emotional engagement and bringing innovation and diversity to data storytelling. On the other hand, from the perspective of customization, creators must consider their scope of applicability when applying our guidelines, especially when moving beyond classical narrative structures into more complex data scenarios. Although our guidance effectively addressed data stories based on simpler data sets, offering a structured method for author-driven linear narrative visualization, their applicability may vary across different storytelling scenarios and data types [37, 62]. For instance, scenarios involving multiple mentors within a chapter of the Hero's Journey or nested narrative structures within a chapter can pose difficulties for creators in filtering, identifying, and processing complex data information. In future work, we aim to strike an optimal balance between generalizability and customization in data storytelling within the Hero's Journey context, creating adaptable frameworks that meet diverse storytelling needs.

8 CONCLUSION

Our study of 48 data videos establishes a framework aligning narrative stages, sound, and visual design with the Hero's Journey's three phases, aiding designers and storytellers in enhancing data video storytelling through a structured approach.

ACKNOWLEDGEMENT

This work has been partially supported by RGC GRF Grant 16210722.

REFERENCES

- [1] F. Amini, N. Henry Riche, B. Lee, C. Hurter, and P. Irani. Understanding data videos: Looking at narrative visualization through the cinematography lens. In *Proceedings of the 33rd Annual ACM conference on human factors in computing systems*, pp. 1459–1468, 2015. [2](#) [7](#)
- [2] F. Amini, N. H. Riche, B. Lee, J. Leboe-McGowan, and P. Irani. Hooked on data videos: assessing the effect of animation and pictographs on viewer engagement. In *Proceedings of the 2018 International Conference on Advanced Visual Interfaces*, pp. 1–9, 2018. [2](#)
- [3] Aristotle. *Poetics*. ReadHowYouWant, www.ReadHowYouWant.com, 2006. [2](#)
- [4] B. Bach, E. Freeman, A. Abdul-Rahman, C. Turkay, S. Khan, Y. Fan, and M. Chen. Dashboard design patterns. *IEEE transactions on visualization and computer graphics*, 29(1):342–352, 2022. [2](#)
- [5] B. Bach, M. Stefaner, J. Boy, S. Drucker, L. Bartram, J. Wood, P. Ciucarelli, Y. Engelhardt, U. Koeppen, and B. Tversky. Narrative design patterns for data-driven storytelling. In *Data-driven storytelling*, pp. 107–133. AK Peters/CRC Press, 2018. [2](#)
- [6] B. Bach, Z. Wang, M. Farinella, D. Murray-Rust, and N. Henry Riche. Design patterns for data comics. In *Proceedings of the 2018 chi conference on human factors in computing systems*, pp. 1–12, 2018. [2](#), [3](#), [7](#)
- [7] J.-A. BACHOROWSKI and M. J. Owren. Sounds of emotion: production and perception of affect-related vocal acoustics. *Annals of the New York Academy of Sciences*, 1000(1):244–265, 2003. [4](#)
- [8] T. Bancks. Beyond the hero’s journey: ‘joseph (campbell) is my yoda’. *Australian Screen Education Online*, (33):32–34, 2003. [2](#)
- [9] W. Bank. Perceptions of indonesia’s inequality, 2015. [3](#)
- [10] J. Boll. Harry potter’s archetypal journey. In *Heroism in the Harry Potter series*, pp. 85–104. Routledge, 2016. [3](#)
- [11] J. Boy, A. V. Pandey, J. Emerson, M. Satterthwaite, O. Nov, and E. Bertini. Showing people behind data: Does anthropomorphizing visualizations elicit more empathy for human rights data? In *Proceedings of the 2017 CHI conference on human factors in computing systems*, pp. 5462–5474, 2017. [2](#)
- [12] J. D. Bradbury and R. E. Guadagno. Documentary narrative visualization: Features and modes of documentary film in narrative visualization. *Information Visualization*, 19(4):339–352, 2020. [2](#)
- [13] V. Braun and V. Clarke. Using thematic analysis in psychology. *Qualitative research in psychology*, 3(2):77–101, 2006. [3](#)
- [14] M. Brehmer, B. Lee, B. Bach, N. H. Riche, and T. Munzner. Timelines revisited: A design space and considerations for expressive storytelling. *IEEE transactions on visualization and computer graphics*, 23(9):2151–2164, 2016. [2](#)
- [15] J. L. Brown and C. A. Moffett. *The hero’s journey: How educators can transform schools and improve learning*. ASCD, 1999. [2](#)
- [16] M. Brütsch. The three-act structure: Myth or magical formula? *Journal of Screenwriting*, 6(3):301–326, 2015. [3](#)
- [17] J. Campbell. *The hero’s journey: Joseph Campbell on his life and work*, vol. 7. New World Library, 2003. [1](#), [2](#)
- [18] J. Campbell. *The hero with a thousand faces*, vol. 17. New World Library, 2008. [1](#), [2](#)
- [19] R. Cao, S. Dey, A. Cunningham, J. Walsh, R. T. Smith, J. E. Zucco, and B. H. Thomas. Examining the use of narrative constructs in data videos. *Visual Informatics*, 4(1):8–22, 2020. [2](#)
- [20] Q. Chen, S. Cao, J. Wang, and N. Cao. How does automation shape the process of narrative visualization: A survey of tools. *IEEE Transactions on Visualization and Computer Graphics*, 2023. [1](#), [9](#)
- [21] Q. Chen, Z. Liu, C. Wang, X. Lan, Y. Chen, S. Chen, and N. Cao. Vizbelle: A design space of embellishments for data visualization. *arXiv preprint arXiv:2209.03642*, 2022. [2](#)
- [22] M. Chion. *Audio-vision: sound on screen*. Columbia University Press, 2019. [3](#), [9](#)
- [23] N. Cohn. Visual narrative structure. *Cognitive science*, 37(3):413–452, 2013. [2](#)
- [24] K. Collins. *Game sound: an introduction to the history, theory, and practice of video game music and sound design*. Mit Press, 2008. [3](#)
- [25] M. Conlen, J. Heer, H. Mushkin, and S. Davidoff. Cinematic techniques in narrative visualization. *arXiv preprint arXiv:2301.03109*, 2023. [1](#)
- [26] V. Dakic. Sound design for film and television. 2009. [4](#)
- [27] S. David. Sound design: The expressive power of music, voice and sound effects in cinema. *Studio City:/snl*, 2001. [3](#)
- [28] S. B. Davis. Interacting with pictures: film, narrative and interaction. *Digital creativity*, 13(2):71–84, 2002. [3](#)
- [29] L. Du, Y. Xiao, and S.-M. Kang. The heroic journey in yeats’s cuchulain plays. *International Journal of Advanced Culture Technology*, 9(3):181–187, 2021. [1](#)
- [30] G. Freytag and E. J. MacEwan. *Freytag’s technique of the drama: an exposition of dramatic composition and art*. Scott, Foresman and Company, Brook, Ill., USA, 1908. [2](#)
- [31] N. Gershon and W. Page. What storytelling can do for information visualization. *Communications of the ACM*, 44(8):31–37, 2001. [1](#), [2](#)
- [32] S. Gilligan and R. Dilts. *The Hero’s Journey: A Voyage of Self Discovery*. Crown House Publishing, 2009. [1](#)
- [33] B. Glaser and A. Strauss. *Discovery of grounded theory: Strategies for qualitative research*. Routledge, 2017. [3](#)
- [34] P. J. Gulino. *Screenwriting: the sequence approach*. Bloomsbury Publishing USA, 2024. [1](#), [3](#), [9](#)
- [35] D. Hug. How do you sound design? an exploratory investigation of sound design process visualizations. In *Proceedings of the 15th International Audio Mostly Conference*, pp. 114–121, 2020. [9](#)
- [36] A. Janes, A. Sillitti, G. Succi, et al. Effective dashboard design. *Cutter IT journal*, 26(1):17–24, 2013. [2](#)
- [37] L. Jiles. Storytelling with data visualization. *Strategic Finance*, 102(6):34–39, 2020. [9](#)
- [38] P. Klinke, S. Verhoeven, F. Roth, L. Hagemann, T. Alnawa, J. Lincke, P. Rein, and R. Hirschfeld. *Tool support for collaborative creation of interactive storytelling media*, vol. 141. Universitätsverlag Potsdam, 2022. [9](#)
- [39] C. N. Knaflic. *Storytelling with data: A data visualization guide for business professionals*. John Wiley & Sons, 2015. [1](#)
- [40] D. Kulezic-Wilson. Sound design is the new score. *Music, Sound, and the Moving Image*, 2(2):127–131, 2008. [9](#)
- [41] X. Lan, Y. Shi, Y. Wu, X. Jiao, and N. Cao. Kineticharts: Augmenting affective expressiveness of charts in data stories with animation design. *IEEE Transactions on Visualization and Computer Graphics*, 28(1):933–943, 2021. [2](#)
- [42] X. Lan, Y. Shi, Y. Zhang, and N. Cao. Smile or scowl? looking at infographic design through the affective lens. *IEEE Transactions on Visualization and Computer Graphics*, 27(6):2796–2807, 2021. [2](#)
- [43] X. Lan, Y. Wu, and N. Cao. Affective visualization design: Leveraging the emotional impact of data. *IEEE Transactions on Visualization and Computer Graphics*, 2023. [1](#), [2](#), [4](#)
- [44] X. Lan, Y. Wu, Y. Shi, Q. Chen, and N. Cao. Negative emotions, positive outcomes? exploring the communication of negativity in serious data stories. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, pp. 1–14, 2022. [2](#)
- [45] X. Lan, X. Xu, and N. Cao. Understanding narrative linearity for telling expressive time-oriented stories. In *Proceedings of the 2021 CHI conference on human factors in computing systems*, pp. 1–13, 2021. [2](#)
- [46] B. Lee, N. H. Riche, P. Isenberg, and S. Carpendale. More than telling a story: Transforming data into visually shared stories. *IEEE computer graphics and applications*, 35(5):84–90, 2015. [1](#), [9](#)
- [47] H. Li, Y. Wang, and H. Qu. Where are we so far? understanding data storytelling tools from the perspective of human-ai collaboration. *arXiv preprint arXiv:2309.15723*, 2023. [9](#)
- [48] W. Li, Y. Wang, H. Zhang, and H. Qu. Improving engagement of animated visualization with visual foreshadowing. In *2020 IEEE Visualization Conference (VIS)*, pp. 141–145. IEEE, 2020. [2](#)
- [49] J. Lu, J. Wang, H. Ye, Y. Gu, Z. Ding, M. Xu, and W. Chen. Illustrating changes in time-series data with data video. *IEEE Computer Graphics and Applications*, 40(2):18–31, 2020. [2](#)
- [50] P. E. McKnight and J. Najab. Mann-whitney u test. *The Corsini encyclopedia of psychology*, pp. 1–1, 2010. [7](#)
- [51] H. Mei, Y. Ma, Y. Wei, and W. Chen. The design space of construction tools for information visualization: A survey. *Journal of Visual Languages & Computing*, 44:120–132, 2018. [2](#)
- [52] S. Mittenentzwei, L. A. Garrison, E. Mört, K. Lawonn, S. Bruckner, B. Preim, and M. Meuschke. Investigating user behavior in slideshows and scrollytelling as narrative genres in medical visualization. *Computers & Graphics*, 114:229–238, 2023. [9](#)
- [53] L. Morais, Y. Jansen, N. Andrade, and P. Dragicevic. Showing data about people: A design space of anthropographics. *IEEE Transactions on Visualization and Computer Graphics*, 28(3):1661–1679, 2020. [2](#)
- [54] M. J. Owren and J.-A. Bachorowski. Measuring emotion-related vocal acoustics. *Handbook of emotion elicitation and assessment*, pp. 239–266,

2007. 4
- [55] D. E. Palumbo. *The monomyth in American science fiction films: 28 visions of the Hero's journey*, vol. 48. McFarland, 2014. 1
- [56] S. Pauletto. The sound design of cinematic voices. *The New Soundtrack*, 2(2):127–142, 2012. 9
- [57] A. Prokhorov. The hero's journey and three types of metaphor in pixar animation. *Metaphor and Symbol*, 36(4):229–240, 2021. 1
- [58] L. Richards. Handling qualitative data: A practical guide. *Handling Qualitative Data*, pp. 1–336, 2020. 3
- [59] D. C. Richardson, N. K. Griffin, L. Zaki, A. Stephenson, J. Yan, T. Curry, R. Noble, J. Hogan, J. I. Skipper, and J. T. Devlin. Engagement in video and audio narratives: Contrasting self-report and physiological measures. *Scientific Reports*, 10(1):11298, 2020. 9
- [60] N. H. Riche, C. Hurter, N. Diakopoulos, and S. Carpendale. *Data-driven storytelling*. CRC Press, 2018. 2
- [61] I. Salselas and R. Penha. The role of sound in inducing storytelling in immersive environments. In *Proceedings of the 14th International Audio Mostly Conference: A Journey in Sound*, pp. 191–198, 2019. 9
- [62] E. Segel and J. Heer. Narrative visualization: Telling stories with data. *IEEE transactions on visualization and computer graphics*, 16(6):1139–1148, 2010. 2, 4, 9
- [63] Y. Shi, T. Gao, X. Jiao, and N. Cao. Breaking the fourth wall of data stories through interaction. *IEEE Transactions on Visualization and Computer Graphics*, 29(1):972–982, 2022. 2, 3
- [64] Y. Shi, X. Lan, J. Li, Z. Li, and N. Cao. Communicating with motion: A design space for animated visual narratives in data videos. In *Proceedings of the 2021 CHI conference on human factors in computing systems*, pp. 1–13, 2021. 1, 2
- [65] X. Shu, A. Wu, J. Tang, B. Bach, Y. Wu, and H. Qu. What makes a data-gif understandable? *IEEE Transactions on Visualization and Computer Graphics*, 27(2):1492–1502, 2020. 2
- [66] C. D. Stolper, B. Lee, N. H. Riche, and J. Stasko. Emerging and recurring data-driven storytelling techniques: Analysis of a curated collection of recent stories. 2016. 2, 9
- [67] J. Tang, L. Yu, T. Tang, X. Shu, L. Ying, Y. Zhou, P. Ren, and Y. Wu. Narrative transitions in data videos. In *2020 IEEE visualization conference (VIS)*, pp. 151–155. IEEE, 2020. 2
- [68] A. Thudt, J. Walny, T. Gschwandtner, J. Dykes, and J. Stasko. Exploration and explanation in data-driven storytelling. In *Data-Driven Storytelling*, pp. 59–83. AK Peters/CRC Press, 2018. 2
- [69] C. Tong, R. Roberts, R. Borgo, S. Walton, R. S. Laramee, K. Wegba, A. Lu, Y. Wang, H. Qu, Q. Luo, et al. Storytelling and visualization: An extended survey. *Information*, 9(3):65, 2018. 1
- [70] C. Vogler. *The Writer's journey*. Michael Wiese Productions Studio City, CA, 2007. 4
- [71] C. Vogler. Joseph campbell goes to the movies: The influence of the hero's journey in film narrative. *Journal of Genius and Eminence*, 2(2):9–23, 2017. 3
- [72] Vox. Teaching in the us vs. the rest of the world, 2020. 4
- [73] Vox. How michigan explains american politics, 2024. 2
- [74] Y. Wang, Z. Sun, H. Zhang, W. Cui, K. Xu, X. Ma, and D. Zhang. Datashot: Automatic generation of fact sheets from tabular data. *IEEE transactions on visualization and computer graphics*, 26(1):895–905, 2019. 7
- [75] Z. Wang, H. Romat, F. Chevalier, N. H. Riche, D. Murray-Rust, and B. Bach. Interactive data comics. *IEEE Transactions on Visualization and Computer Graphics*, 28(1):944–954, 2021. 2
- [76] L. Xie, X. Shu, J. C. Su, Y. Wang, S. Chen, and H. Qu. Creating emordle: Animating word cloud for emotion expression. *IEEE Transactions on Visualization and Computer Graphics*, 2023. 2
- [77] L. Xie, Z. Zhou, K. Yu, Y. Wang, H. Qu, and S. Chen. Wakey-wakey: Animate text by mimicking characters in a gif. In *Proceedings of the 36th Annual ACM Symposium on User Interface Software and Technology*, pp. 1–14, 2023. 2
- [78] X. Xu, A. Wu, L. Yang, Z. Wei, R. Huang, D. Yip, and H. Qu. Is it the end? guidelines for cinematic endings in data videos. In *Proceedings of the 2023 CHI Conference on Human Factors in Computing Systems*, pp. 1–16, 2023. 1, 2, 3
- [79] X. Xu, L. Yang, D. Yip, M. Fan, Z. Wei, and H. Qu. From ‘wow’ to ‘why’: Guidelines for creating the opening of a data video with cinematic styles. In *Proceedings of the 2022 CHI Conference on Human Factors in Computing Systems*, pp. 1–20, 2022. 1, 2, 3, 9
- [80] L. Yang, A. Wu, W. Tong, X. Xu, Z. Wei, and H. Qu. Understanding 3d data videos: From screens to virtual reality. In *2023 IEEE 16th Pacific Visualization Symposium (PacificVis)*, pp. 197–206. IEEE, 2023. 1
- [81] L. Yang, X. Xu, X. Lan, Z. Liu, S. Guo, Y. Shi, H. Qu, and N. Cao. A design space for applying the freytag’s pyramid structure to data stories. *IEEE Transactions on Visualization and Computer Graphics*, 28(1):922–932, 2021. 2, 3, 9
- [82] J. Yorke. *Into the woods: A five-act journey into story*. Abrams, 2014. 4