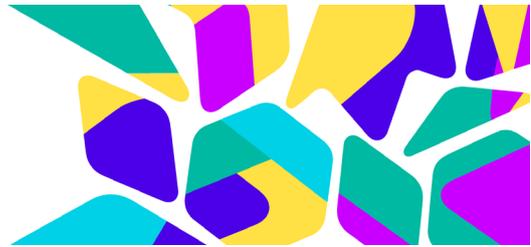


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The Role of Narrative Thinking in Design: Taking the Mathematical Hall of the London Science Museum as an Example

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Abstract: In daily life, people are accustomed to using narrative thinking to understand, communicate and disseminate information naturally and flexibly. Applying narrative thinking to design is a practical and powerful strategy; here, narrative thinking is the default method and mechanism that supports design. This article combines the research results of narrative and narrative thinking in literature and psychology, and draws on and compares the research methods of design thinking to roughly outline the characteristic framework of narrative thinking purpose, process, cognition and evaluation. It then further integrates the characteristics of narrative thinking into the specific case of the Mathematics Hall of London's Science Museum for innovative research, analyses and interprets the role of narrative thinking from the aspects of theme deduction, meaning construction, integration of elements and interpretation of experience. The paper looks forward to gaining a certain understanding and grasp of the application of narrative thinking in design.

Keywords: narrative; narrative thinking; design; display space

1. Introduction

Narrative encompasses the basic rules and power for how people understand the world, and it is also the basis for human expression of experience. Expressing wishes through narratives is not only reflected in daily life, it also extends to all areas of human society. Under the influence of the narrative turn, more and more design activities have begun to apply narrative research and practice, and the exploration around narrative has become an emerging topic in the current design community. However, in the existing research, the interdisciplinary application of design narratives so far has focused on the concepts, techniques and rules of literary narratives, the deeper narrative thinking logic and mechanism has received very little attention. This article takes a different approach, using narrative thinking as a method of research design. In addition, this method combines



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literature and psychology, and is based on a narrative theory in literature to outline a set of narrative thinking contours suitable for explaining design. This formulation assumes that narrative thinking can be used as a systematic method of design; that is, narrative thinking is an interpretable pattern feature. This article also uses a specific case of museum exhibition space to analyse the application of narrative thinking in design.

2. Narrative and narrative thinking

2.1 Narrative

Narratives are most often referred to as ‘story’ and ‘storytelling’ (Chatman, 1980; Brooks, 1992; Abbott, 2002). This dual concept is mainly derived from narratology, but also includes literary studies, anthropology, psychology and sociolinguistics. In fact, whether it is narratology or other disciplines, the focus of narrative is ‘how to tell a story’, not ‘what is a story’, and it refers to the techniques, methods and rules of storytelling (Shen & Wang, 2010; Herman, 2009). In traditional narratology, narrative must have two or more related events—real or fictional—and the events that can be called narratives must be related to people. Without characters, events, such as natural phenomena, cannot be regarded as ‘events’ of narratives. Second, narratives need to be mediated; there is no narrative in life, narratives are artefacts (Shen & Wang, 2010, p. 2; Prince, 2011, p. 137; Zhao, 2013, p. 10). Narrative as a purposeful communication activity: ‘It is someone telling others, on some occasions, for some purpose, telling something happened to someone or something’ (Herman, & Phelan, p. 3). In fact, narrative is not only a communication activity, it is also a common way for humans to organize their personal survival experiences and social and cultural experiences. Narrative is everywhere, and it is closely related to human life, with different themes and varieties, transcending the country, history and culture, just like the existence of life.

What mechanism supports the widespread application of narrative? In the academic tradition, some scholars point out that narrative functions as ideogram, media, logic, transformation and aggregation (Meng, 1989, p. 18). Sarbin (1986, p. 9) regards narrative is a way of organizing plots and actions compared to other more traditional organizing principles, it is a combination of ordinary facts and marvellous creations, time and place in this organization are causally combined. Narrative explains how things happen and why they happen through a combination of related events (Morgan, 2017). It is strongly believed that narrative is a human ability that is genetically closely linked to our thinking, as if it were our innate ‘deep structure’ (Abbott, 2012, p. 4). In a nutshell, the wide application of narrative is the function of the narrative mechanism, while the deeper consciousness is affected by narrative thinking.

2.2 Narrative thinking

Since the 1980s, narrative has been proposed as a mode of cognition. Bruner published *Actual Minds, Possible Worlds* in 1986, which pointed out that human beings have two

different cognitive models: the paradigm mode (also called the scientific mode) and the narrative mode. The paradigm mode mainly uses the method of rational deduction and logical analysis; and the narrative mode deals with human beings or human-like intentions and behaviours and marks the changes and results of their processes. The former focuses on truth and facts, and the latter focuses on the possibilities and vividness of expression (Bruner, 1986, p. 11). The results of scientific thinking are often general and abstract, while the results of narrative thinking are often specific and unique (Robinson & Hawpe, 1986, p. 114). Herman (2009, p. 7) points out that narrative is a way of understanding cognitive structure or experience, and as a resource of communication and interaction, it can be shaped by the practice of storytelling. Robinson and Hawke (1986, p. 111) emphasized that narrative thinking is an inspiring method of causal thinking; the power and versatility of narrative thinking is rooted in cognitive schemas, which are the basis of any story. Robinson and Hawke (1986, p. 112) also believe that narrative thinking involves creating a fit between the situation and the story schema and establishing a suitable one, that is, creating a story from experience is an enlightening process that requires skill, judgement and experience. Rein and Schon (1977, p. 115) argue that the narrative schema is actually a framework process that strategically organizes and drives a solution. As part of this narrative psychology, theorists such as Wertsch (2002, 2008) proposed that narrative templates are the basis of collective narrative, so these templates constitute a common understanding and memory of events and experience. In summary, narrative thinking is mainly thinking through storytelling. It is not only different from paradigm thinking (scientific thinking), it is also closely integrated with paradigm thinking. This thinking mode is a basic way of thinking for humans.

3. Analysis of the mechanism and logical characteristics of narrative thinking

Narrative thinking is not just a human cognitive model. In fact, narrative thinking has become a basic organizational mechanism. The following will selectively explore the mechanism and logical characteristics of narrative thinking from the aspects of purpose, process, cognition and evaluation that are relevant and helpful for design.

3.1 The main purpose is to interpret

Narrative thinking is different from the scientific and rational way of thinking. The latter mainly connects things through positivism, reasoning and logic. As a basic way to understand the world, narrative grasps things and understands the world through plotization (Zhao, 2013, p. 1). In contrast to rational thinking, which aims at prediction, control and change, narrative thinking aims to understand and interpret. It can be said that narrative thinking focuses more on explaining things, and the main purpose is interpretation (Xiang, 2014). This mechanism of interpretation organizes a series of independent events through narrative logic to obtain continuity, and establishes a connection between these independent events. Put another way, if you can't understand and explain a problem, you can't talk about predicting, controlling and solving the problem.

If the characteristics of narrative thinking and design thinking can be compared with a feasible hypothesis, it can be determined that, compared to design thinking, focusing on problem discovery and problem solving (Jensen, 2014), in design, the goal is to create as many new specific conditions as possible to meet specific needs (Farrell & Hooker, 2014).

Narrative thinking emphasizes the construction and interpretation of meaning—specifically, to explain a problem. In contrast to solving problems, it is necessary to provide a set of controllable solutions through analysis and prediction, and interpretation provides a method of meaning-based understanding. At the same time, design thinking and narrative thinking are interdependent and complementary. In the process of design thinking, problems such as finding problems, locating problems, developing problems and solving problems are inseparable from the necessary explanations. Therefore, in design thinking, it is often necessary to use narrative thinking to present and explain various processes, such as using storyboards and scene diagrams to explain a problem. For design thinking, good ideas cannot be understood, recognized or implemented unless they are explained well. At the same time, in a design, the problem itself needs to be presented in a specific way. In this way, the design symbol becomes the carrier of explanation. In other words, any interpretation and description must have a carrier and a medium and must have a specific form and symbol. In general, narrative thinking is complementary to design thinking and has a characteristic that emphasizes ‘explaining the problem’.

3.2 Structured process driven by plot

The narrative thinking process brought about by the purpose of interpretation is characterized by a plot-driven structure. Plot is not only a noun, it is also a verb. Aristotle (2015(p. 37) pointed out that the plot is the most important one of the six elements of tragedy, and ‘the plot, that is, the arrangement of events’. Plots are often viewed as an important narrative technique of art processing to achieve a heterogeneous effect. The narrative mode mainly grasps things and understands the world through plot (Zhao, 2013, p. 1). Without plot, the events, fragments, actions, etc. in the narrative cannot form an interconnected and intentional whole, and cannot be understood (Brooks, 1992, p. 5). Plots emphasize the value of causal events, the plot has the power to promote the development of narrative (Herman, 2016, p. 60). Plots can make complex events clear and organized. People describe life events through plot, and listeners understand life through plot.

A structured process, such as literature, must first have an idea or theme after which the narrative can be developed by adding details with specific sentences and paragraphs, which is all driven by the plot. This process is different from the traditional design process, primarily, in the different goals of the two. The generalised design process is to discover the problem through the material, and finally form a solution; the result is a funnel form from large to small. The design process includes not only problem solving but also problem finding, and it is an iterative process (Steen, 2013). The structured process of narrative thinking is different. It is mainly through the connection of the plots between the materials to form a higher-level narrative unit, which ultimately forms a complete novel, script, etc.

The process of narrative thinking vividly and from multiple angles illustrates the theme and concepts through a complex structured work, and finally forms a multi-dimensional and complex structure.

3.3 Context-based cognitive approach

Narrative forms events into contextual meaningful bodies. In contrast to the logic-scientific model, which seeks conditions of universal truth, the narrative model requires a special connection between events. The explanation in the narrative mode is contained in the context, while the logical-scientific explanation is inferred from time and space (Berger, 2006, p. 10). In contrast to illustration science, which uses abstract thinking and logical reasoning, the narrative thinking process mainly depends on specific, plot-related contextual relationships. Narrative is an active mechanism for connecting different objects (Quesenbery & Brooks, 2014, p. 22). It can be said that narrative thinking is a relationship-based way of thinking that emphasizes placing objects in a logically related situation, thereby gaining a holistic grasp of the story.

Narrative thinking brings to the user a kind of relevance and situational cognition. This kind of cognition can enable the viewer to realize that the association and arrangement of elements have a time relationship and a causal relationship. The content and meaning of the interpretation are interconnected; for example, you can trace the cause forward through the effect, or infer the effect through the cause. Narrative thinking is a situational cognitive method that logically associates the objects of meaning interpretation to form a context. Under this logic, discourse and symbols are not presented in isolation, but instead form a background and a figure relationship. In addition, the situational cognition of narrative thinking is not static and solidified; it is a dynamic process of moments and slices that are constantly developing and marching forward. In this kind of situational dynamic process, ideas, viewpoints and meanings are constantly produced, so that the past, present and future form a whole meaning that contains thought and wisdom, for example, using a situation to explain the motivation or purpose of a design so that the design is in an interconnected whole. With the help of the situation, the user's imagination can be triggered, bridging whatever gaps there are in understanding. The situation-based information exchange method is very natural and rich. In this way, a stable carrier is prepared for the narrative; experience can be built on it, and it can be experienced from multiple angles (Wurman, 2001, p. 36).

3.4 Emphasis on vividness as the evaluation criterion

Vividness in the narrative thinking model is used as the basis for the evaluation criteria. Bruner (1986, p. 11) points out that the exemplifying pattern is convinced by authenticity, while the narrative paradigm is convinced by lifelikeness. Foster (2015, p. 81) also believes that a good story should be like a living organism. Aristotle (2015, p. 72) described this vividness thousands of years ago: 'in the creation, the scene in the play should be tried hard, and only then can you see clearly—as if in the event in the field—can be properly handled

without neglecting the contradiction, and every effort should be made to express it in various languages'. It can be said that the emphasis on narrative thinking is more vivid than exemplified thinking, which emphasizes rationality and scientificity.

To sum up: vividness refers to lively, active, impressive and dynamic beauty (He,2010). From the perspective of experience, it is mainly the richness of the information presented by the media objects to the audience. The vividness can also be decomposed into two dimensions: breadth and depth. The former refers to the senses that the media can stimulate (such as hearing, vision, and touch). The latter refers to the quantitative extent to which the media can stimulate the senses (Steuer,1992). In general, specific and detailed information is more vivid than abstract information, and pictures and videos are more vivid than text (Kim, 2015, p. 92).

Specific to the field of narrative, the vividness is reflected in several aspects. The first is specific vividness. Narrative avoids abstraction and rises to the concrete (Prince, 2013, p. 146). As for the interpretation of meaning, the specifics are not abstract, not general, and the details are clear. From the perspective of narrative thinking, this kind of concrete interpretation requires that meaning be placed in a situation where various elements are related to the whole. This specific vividness corresponds to the requirement in the design that it is not Euclidean geometry, but the pursuit of rich details and rich content.

Second, the vividness evaluation standard in narrative thinking requires the narrative to emphasize particularity. The narrative focuses on the particular rather than the general (Prince, 2013, p. 146). It emphasizes a personality to find the difference from the ordinary; it requires keen insight and expression with unique and real needs, which are different from the focus group method, future scenario method, joint analysis method and questionnaire method in design thinking. It emphasizes each living individual, not the general nihilistic group. In fact, design needs to be aware of the real particularity and differentiation, not homogeneous standardization.

3.5 Frame diagram of narrative thinking

The above-mentioned mechanisms of narrative thinking do not operate independently and are often intertwined. Narrative thinking with interpretation as its main purpose needs to be supported by a set of theme-oriented structured processes. This structure is a kind of human mental activity that cooperates, influences and interacts. This thinking mechanism can be consciously marked and explained, which can be further applied in design.

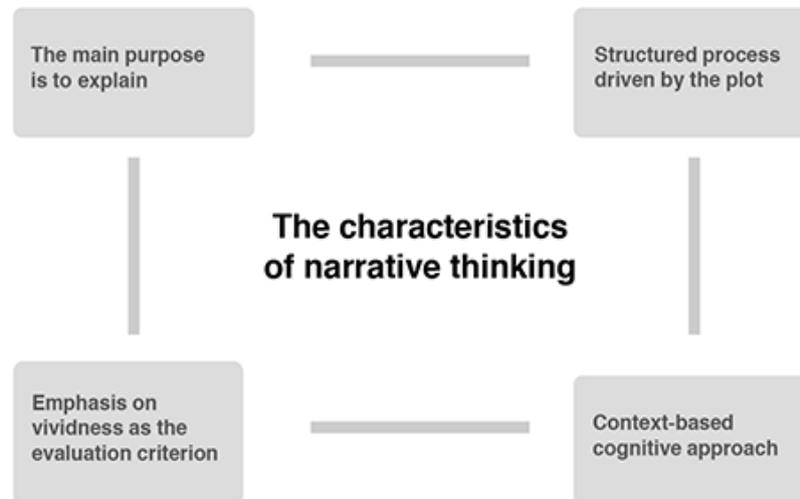


Figure 1 Frame diagram of narrative thinking

4. Taking the Mathematics Hall in London's Science Museum as an example

London's Science Museum, located in central London, has a long history of 150 years. It was founded directly from the Crystal Palace World's Fair held in London in 1851. This fair is usually regarded as the beginning of modern exhibitions. The Mathematics Hall was designed by the famous architect Zaha Hadid's studio. It was opened in 2016 and is a permanent exhibition hall. Since its opening, it has been well received and regarded as a star exhibition hall of the Science Museum. Taking the Mathematics Hall as a case to analyse in depth the role of narrative thinking in the design of museum exhibition space, it is undoubtedly of practical and academic significance. The idea is to apply the mechanism and logic of narrative thinking to spatial design and use the mechanism of narrative thinking to reinterpret and grasp the design.

4.1 Focus on thematic interpretation

'Theme' is derived from the ancient Greek word *thema*. The theme of a work is the idea or concept on which it focuses. The theme emphasizes how the content is related to real life, how life is described, and the various problems, challenges and experiences of life (Brooks, 2014, p. 114). More broadly speaking, the subject is the meaning of the work (Prince, 2016, p. 231). Whether it is a novel, a play or a display space, the theme is one of the most important core elements of a work. Works without a theme often become loose material piles, fragmented into scenes without cohesive elements. For museum exhibition space, a powerful theme can not only integrate scattered information into a meaningful system, it can also play a role in commanding the design of the space and help the audience recognize and understand the meaning of the display.

In narrative thinking, the structured process mechanism aims at interpretation driven by

plot that is, in fact, inseparable from the theme. Applying narrative thinking to the design of museum exhibition space will help make the design pay closer attention to the theme. Attaching importance to the theme means that the design needs to realize that the task is not only to solve the problems of form and technology, but also to reflect the ideas, concepts and meaning of space in the design. For the design of museum exhibition space, attention to the theme can also standardize and unify various elements in the design, which helps develop logical display content and enhance the audience's awareness of the display. Focusing on the theme requires that the theme be reflected and strengthened in the design on the one hand, and all designs require a theme-based framework and strategy. On the other hand, if there is no theme in the requirements given in the previous period, the design effort is required to construct the theme in the design so that the design is more thoughtful and soulful.

The theme of the Mathematics Hall's presentation is 'How Mathematics Shapes Our World'. This theme indicates that the design of space needs to explain and show mathematics around life and show how mathematics is related to our world of life. Based on the design of the exhibition space, the theme is not described in words, but in a visually-oriented way. Good narrative theme needs to have a certain conceptual meaning to avoid the superficial and obscure as much as possible (Lu, 2018, p. 67); it needs to arouse the topic and have multiple interpretations (Hertzberger, 2017, p. 101).

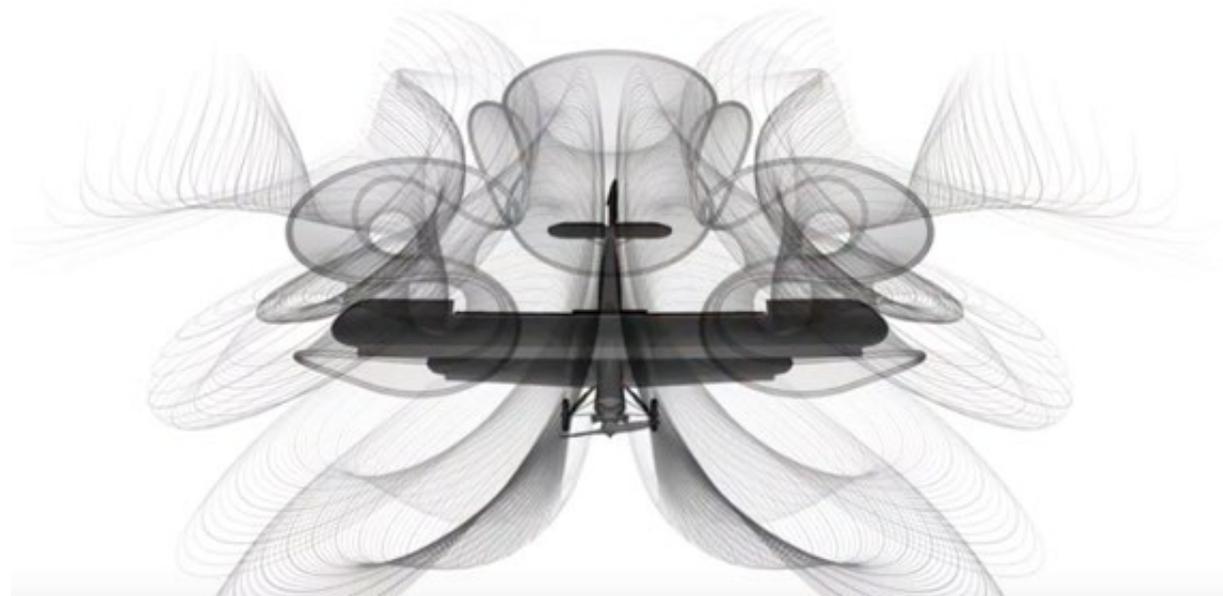


Figure 2 Thematic interpretation of the exhibition space in the Mathematics Hall of London's Science Museum

The spatial interpretation of the Mathematics Hall theme was inspired by the daughter of the famous British poet and mathematician, Lord Byron, and computer program founder Ada Lovelace. The design of the plan (2015) coincided with the 200th anniversary of Lovelace's

birth. Her 'Notes' reveal the abstract world and logic of the analysis engine. The application of mathematics is extremely valuable, making her famous in the mathematical world. The Science Museum hopes that the Mathematics Hall does not simply display academic mathematics, but emphasizes the application of mathematics. It is necessary to describe mathematics as a practice that affects our technology and changes our way of life. It reflects that mathematics has always been a core tool to promote human understanding of the world and the building the world. The designer took the tribute to the great mathematician as the interpretation of the theme of the space. At the same time, the designer also hopes that the design of this exhibition hall can inspire and encourage more people to participate in the world of mathematics, let the audience experience the innovation and driving of mathematics in daily life from a multi-dimensional perspective, and satisfy the audience's multi-dimensional exploration desire. Eventually, the visual design of the Mathematics Hall was an adaptation of a 1929 airplane. The streamlined space was used as the visual symbol of the overall space. This symbol is directly derived from the concept of aircraft aerodynamics, and this aerodynamics and mathematical geometry and calculations are closely related. Based on this, the design concept was transformed based on aerodynamic space calculation, and its theme is interpreted into a giant space installation (see Figure 2). Not only can the theme of mathematics be narrated through this design, it can also be a space of intention that stimulates the audience's thinking and resonates with the theme so that the space has a narrative event nature and symbolic allegory.

Storytelling cannot exist without themes. Based on narrative thinking, the museum's display space is the same as a novel or a play. Only by paying attention to the theme in the creation and recognizing the value of the theme can the work have soul so that it can reach the audience more deeply. The heart can make the audience think and feel and help them remember and cherish the story.

4.2 Enabling meaning constructs

Narrative thinking can empower the meaning structure in museum exhibition space design because the ontology of narrative thinking has the ability to construct meaning. As Zhao Yiheng (2013, p. 168) said, events in both the empirical world and the imaginary world need to form meaning through narrative, that is, meaning must exist in various narratives. The narrative process is the process by which people give meaning to events and express this meaning. This 'empowerment' process is the most basic cultural and spiritual behaviour of human beings (Li, 2012). Narrative can give display imagination and create meaning. (Bedford, 2014, p.133). Using narrative mechanism in museum display can create an attractive, meaningful and unforgettable narrative environment (Maclead, Hanks, Hale, 2012). Applying narrative thinking in the design of museum display space can empower meaning, which is a value-added structure of museum display space.

For museum exhibition spaces, this kind of empowerment is first reflected in the infusion of meaning into the structure of meaning. In the organization of meaning, narrative is not a mechanical structural combination. It is destined to involve the narrator's perspective,

position, ideas and emotions. These factors will undoubtedly increase the power of meaning construction. It can be said that the application of narrative thinking can make the meaning structure of the museum display space no longer provide a straightforward and arbitrary answer, but a story that compresses emotion, wisdom and philosophy. In this way, narrative can be interpreted and metaphorized into a story with plot, whether historical, biological, cultural or chemical, and then interpreted through this narrative logic among many disciplines. For example, in the theme structure of the Mathematics Hall, there is the connotation of the designer's tribute to Lovelace. With this layer of connotation, the concept of space will not be so pale; it will be more meaningful and embody certain emotions. The theme itself also contains certain ideas and concepts. Here, the word 'our' shows that the meaning construction of this theme has an affinity perspective, which suggests that the interpretive position is to integrate the narrator and the experienter, and the speaker strives to stand on the viewer. This perspective can easily immerse the audience in the story and create a fascinating desire to continue reading; it can make the audience feel the connection between the theme and themselves, and can share experiences with others.

Second, the construction of meaning in narrative thinking empowers meaning interpretation. When a person is telling his or her own story, it is the subject 'I' who constructs the story with the object 'self' as his/her principal, and it is also the subject 'I' who examines and reflects on the object 'self' (Shi, 2004). Storytelling also gives designers and viewers a sense of empathy. Telling stories requires imagination as does understanding stories. A good story is reasonable and unexpected. This requires that storytelling provide the audience with a plot gap and encourage them to participate in the construction of meaning together, which is essentially an inspiring meaning construction. For example, the organic giant luminous body device at the centre of the exhibition space of the Mathematics Hall unifies the entire hall in a space environment with a stage effect. From the perspective of meaning structure, this device inspires the audience to respond and think through the strong expressiveness of the device, and then complete and fill in the blanks in meaning. At the same time, the answer to this blank is not the choice of A and B, but it gives each person a certain degree of freedom, which is open and inspiring. At the same time, this installation form itself reflects an open, decentralized and inclusive form meaning, which brings the idea to cater for the multicultural needs of contemporary audiences' participation, curiosity and sense of self, and encourages the audience to explore and consider the entire space and its theme. From the perspective of the construction of spatial meaning, the installation of the Mathematics Hall has formed a relatively independent design landscape, which has created a complex interface, has a multi-dimensional sense of layers and enriched the dimensions and connotations of the space interpretation and experience—a value-added meaning construct.



Figure 3 Thematic interpretation of the exhibition space in the Mathematics Hall of London's Science Museum

In addition, the empowering significance of narrative thinking lies in digging through the stories behind the exhibits in an effort to find new insights and value, as shown in Figure 3, for small aircraft. This is not a brief introduction to what the aircraft is called, when it was produced, etc. Instead, it first makes a very clear statement: without mathematics, the public's dream of flying would be ruined. This narrative method can psychologically hook the audience to further explore the subsequent narrative development.

Then the storyline development of this exhibit is implemented in five units: 1 the birth of civil aviation, 2 mathematics and the civil aviation industry, 3 aircraft safety 4 Frederick Handley Page (British aircraft designer, engineer, aviation entrepreneur, and designer of this exhibit), and 5 the great progress in aircraft design. A more detailed narrative is set up under each unit. It can be seen that this kind of display has not stopped at the introduction of the object itself, but has developed a valuable story around the exhibit, thereby making the exhibit more meaningful. In this way, for the construction of the meaning of empowerment based on narrative thinking, the interpretation of the exhibit is not to stay on the external form of the exhibits, but to dig deeper into the story behind the exhibits, strive to find new insights and value meanings, and activate and excavate the exhibits. The historical experience and culture behind it enrich the content of the exhibits. Only in this way can the audience obtain deeper satisfaction and leave an impression when interpreting the exhibits.

4.3 Rules for integrated elements

Narrative thinking can also provide logic and rules for integrating diverse elements. The narrative has a law of interconnected and intentional elements (Brooks, 1992, p. 5). For the

museum exhibition space, the elements in the space are like the words and phrases of a written text. Although they have independent forms of existence, they cannot present the theme and meaning independently. This requires grammatical connections and combinations between certain logical relationships, so as to integrate them into higher-level spatial elements, such as sentences and paragraphs. The narrative is a whole, a continuous complex of events (Chartman, 2013, p. 7). In this way, narrative thinking can help the scattered and disordered spatial elements to be integrated into a larger spatial structural unit with context and logical order and promote the development of the plot. Because this kind of spatial structure unit has narrative logic and order, it is easy for the audience to perceive and experience it, and ultimately explain and understand the meaning of the overall display. To sum up, narrative thinking can provide two main types of grammar for the integration of display space elements: time-based element integration and theme-based element integration.

The integration of elements based on time means that the events described in the narrative are organized on a time axis (Prince, 2013, p. 65). In the real world, there is usually no obvious time relationship between ‘events’ or ‘elements’. This is the actual state of existence of the world. The museum’s display needs to be interpreted. If there is no order relationship between the elements in the display space, it will be difficult to understand because it is too scattered. For narrative thinking, the significance of the integration method based on time elements lies in the ordering of the elements spatially in order of time to make the transmission of meaning possible. Time focuses on beliefs and demands for a sense of order and certainty in the world (Yang, 2007, p. 42). The integration of spatial elements based on time has a strong sense of narrative structure, clear guidance and clear order. From the perspective of the fluidity of time, integrating elements according to time is intuitive because history itself is immersed in the flow of time, and recreating history is organized to make the flow of time visible and allow for the audience’s perception and experience.

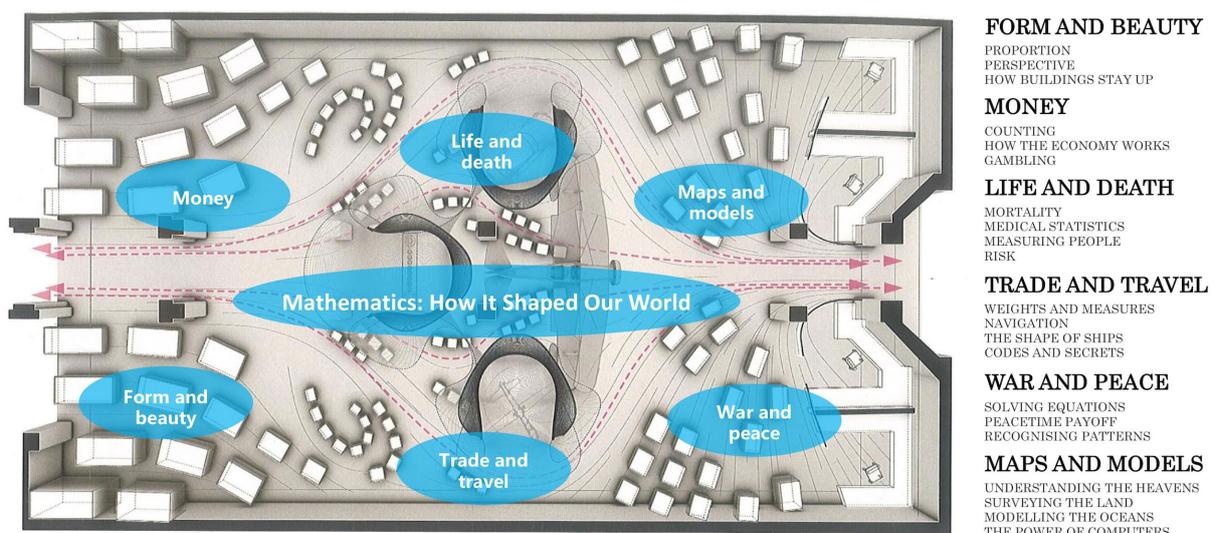


Figure 4 Thematic space layout

Of course, not all museum display space elements can find the chronological relationship associated with them. In this case, themes can be used to integrate the elements to form a related spatial structure. The integration of theme-based display elements is to group them into a series of sub-themes that can be associated with the primary theme. The characteristic of this narrative connection is that each element in the space has an internal thematic relationship, and there is no time sequence. Each 'theme' is equally important. However, care needs to be taken to ensure that the audience remains connected to the entire subject (Locker, 2011, p. 9). The designers of the Mathematics Hall chose this method to integrate the elements, as shown in the figure below. It contains six sub-themes and 21 terminal themes. From a logical perspective, there is no obvious chronological order between these subtopics and terminal topics, so it is suitable to integrate spatial elements in a thematic way (Figure 4). Based on narrative thinking, the integration of spatial elements based on themes enables the 21 terminal themes and the overall theme to be closely centered around the theme of mathematics, which can produce a clustering effect. The spatial structure layout brought by this integration of elements is open, and viewers can freely choose interesting points of interest for understanding and exploration. On this basis, different display methods can be set according to each independent terminal theme, such as physical models, visual data display, video loop playback, interactive query devices, etc., to enrich the development and expressiveness of the narrative. The logic-based integration of elements based on the theme of the Mathematics Hall is to use the theme to lead and make coherent the entire space, and guide the creator to further develop specific spatial details through the framework. In this way, the theme guides and regulates the structure of the space. It will not focus on the specific details and ignore the initial goals and directions. It will continuously enrich and emphasize the meaning and value of the theme in the process of spatial expression.

The internal power of narrative thinking promotes the integration and development of elements. The motivation of the narrative moves the narrative process from the beginning, through the middle, to the end (Phelan 2016, p. 6). The motivation of narrative thinking enables the elements in space to form a fusion and symbiotic relationship, rather than independent and obtrusive elements, which allows the audience to actually feel the sense of order and art brought by integration in the experience. For the design of museum exhibition space, the motivation provided by narrative thinking is not a single-channel advancement, but a binary opposite transformation relationship; that is, the museum exhibition space provides the potential of narrative motivation, and the development of this motivation needs the action and reading of the audience to activate and construct, so the plot is derived from the interaction between the audience and the exhibition space. It is narrative power that drives this interaction and promotes the development of space into a continuum with overall significance. In this process, we must always consider the motivation of the audience to read, combine the power of spatial development and the power of their experience to promote orderly display space development, feedback and conversion. Here, the museum display space is a kind of dynamic field composed of complex elements.

4.4 Providing a credible interpretive experience

The narrative thinking based on the vividness as the evaluation standard can also provide a credible means of interpretation for the museum's exhibition space discourse experience. The mechanism of narrative lies in believable suggestions and recognition (Zurlo & Cautela, 2014). The credibility of the knowledge generated by science is mainly based on objective facts as the logical basis and the standard is consistency and testability, while the credibility of narratives mainly comes from fidelity and vividness. The narrative 'truth' is judged by its plausibility rather than verifiability (Xiang, 2014). Specific to the design of museum exhibition space, the vivid and credible interpretation experience mainly comes from the role of fiction and imagination in narrative thinking.

Non-fictional scientific thinking often tells us how life is, and fictional narrative thinking tells us how life should be, it is a pursuit of realism and poetry. Fiction refers to the relationship between a world and things outside its boundaries (Ronen, 2004, p. 15). Without fiction, there is often no narrative (Peng, 2019). From this perspective, we can understand that narrative is fictional, and it is the product of creation, imagination and construction (Peng, 2016). The Mathematics Hall itself is actually a kind of spatial fiction, a real and poetic construction. Each specific mathematical story does not tell the audience exactly what mathematics is, but based on certain exhibits, vivid scenes are formed through fiction to more vividly explain what mathematics can do, how mathematics affects and changes our lives. These do not need to emphasize the authenticity of these scenes here, but focus on the vividness of the narrative of these mathematical stories, and then use this vividness to capture the audience's attention, so they can understand and recognize the purpose and appeal of the display.



Figure 5 Space narrative discourse

The credible narrative interpretation method is also inseparable from the human imagination, which can find the inner structure between facts beyond the trivial and the grand (Palmer & Jankowiak, 1996). The imagination in narrative is an artistic method based on fiction and reality, the way in which the mind blends fiction into facts. Imagination has the function of connecting known and unknown meanings, and it has the function of generating presence and evoking absentness (Folkman, 2014). It is more purposeful than reasonable and points to specific conclusions, while imagination is derived from the experience of individuals and organizes the material relatively loosely or casually (Pauwels, Meyer, Campenhout, 2013). Narrative requires no empirical facts, but consciously selects and reorganizes the human mind, and then forms a narrative whole with intrinsic meaning (Zhao, 2013, p. 15). Compared with history and facts, the narrative of the Mathematics Hall is not a reproduction. It is formed by the fragmentation of experience and facts through imagination and cooperation, which forms the experience and facts and clarifies the meaning of the structure. So narrative imagination can make the perfect combination of events in narrative. On the other hand, it can also bridge the gap between readers and authors so that narrative communication can proceed normally. To some extent, imagination can trigger the emotions of the listener, and it can help the listener complete the direct leap beyond linear logical thinking to a certain extent (Quesenbery & Brooks, 2014, p. 23).

For the designers of the Mathematics Hall, the credible interpretation experience requirement does not just rely on history, it also requires active and appropriate fiction, positive imagination. Narrative thinking can fuse fiction and imagination together to form a chemical medium that connects multiple elements such as history, society and culture. It can be said that the space is limited and the story is unlimited. In this way, narrative thinking can construct the exhibition space of the Mathematics Hall into a miracle, a lifelike and infectious interpretative experience.

5. Discussion and Conclusion

In fact, the study of narrative thinking involves knowledge of many disciplines, and it is difficult to explain the complex content in an article. The main purpose of this article is to try to explore some of the main characteristics of narrative thinking that can be used in design with reference to the way of design thinking. Of course, this position is based on the differences and comparability assumptions between the two disciplines. For the design of the museum exhibition space, the application of narrative thinking helps the theme of the exhibition space pay closer attention to interpretation and expression. Narrative thinking can also be used as a value-added structure to give meaning to the space. Structure can provide an integration rule for the elements of the exhibition space and can provide a credible interpretative experience. In summary, as shown in figure 6, for the design of museum exhibition space, narrative thinking is both an interpretive mode and an experience mode; one can either interpret the museum exhibition space through narrative or experience it through narrative. As shown in the figure, the four main characteristics of the narrative thinking on the left side of the figure can be basically applied to the design of the exhibition

space of the museum, which is illustrated by light colored lines. Dark lines indicate that the features on the left are the key areas that are applied to the specific theme on the right. For example, the structured process is mainly related to meaning construction and element integration, and the evaluation annotation is mainly related to interpretation experience.

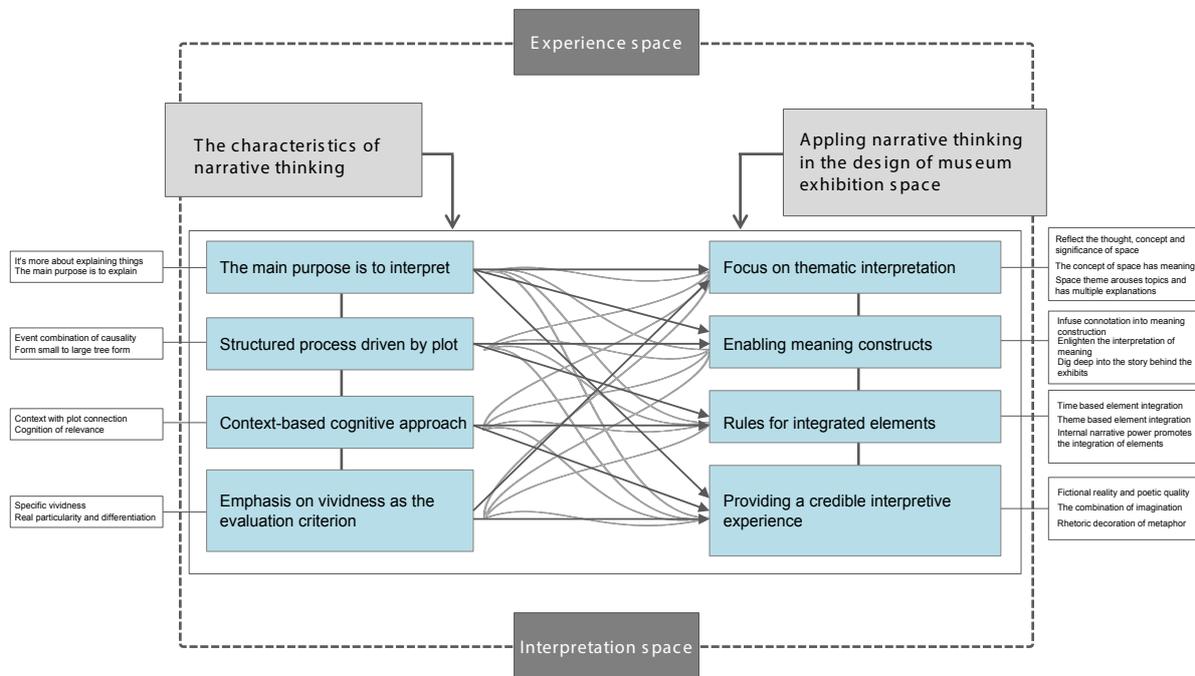


Figure 6 Frame diagram of narrative thinking applied in exhibition space

Contemporary design is not only seen as a professional system and a special skill, it is also seen as an art of communication (Buchanan & Margolin, 2010, p. 1). Based on this background, the museum display space, no matter the form, the needs of the audience or the standard of the experience, no longer has a fixed definition, but it varies with time and place. The museum display space has gradually changed from the earliest place for preservation to a public space that encourages participatory experiences, becoming a part of popular culture, a cultural product that integrates the attributes of learning, leisure, tourism and communication. In this context, the design of museum exhibition space is more concerned with artistic aesthetics and technical aesthetics (Lorenk, Sconick, Berger, 2008, p. 12). These spaces put emphasis on participation and interaction and strive to improve the efficiency and effectiveness of the information displayed through sound, light and electricity; display design that emphasizes the experience of information itself focuses on cognition and emotion of reading information (Lu, 2002, 14). Inquiring into the design of the museum's display space based on narrative thinking is actually a choice, that is, choosing to explore the design language itself with a language that is internal to human experience and structure. If this exploration cannot outline design thinking, the doctrine, at least, also proposes a museum display space design skills and topics, which deserve further research.

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