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A comparative case study of two immersive learning experiences in museums

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Abstract

Art and history museums are increasingly adopting multiple sensorial technologies, challenging people to reconsider how these immersive museum experiences may add to learning art and history. This study explores the use of emerging technologies in museum exhibits, and how it reshapes art and history education in museums. Comparative case study methodology is used to analyse differences and similarities between two immersive augmented reality and virtual reality exhibitions in the Netherlands. While Case 1 offers a structured, guided experience integrating historical artefacts, Case 2 is more open-ended, prioritising imaginative engagement. Drawing on these cases, we posit the construct of immersive learning experiences in museums and reflect on how they relate to traditional museum learning. Interaction and multimodality emerge as critical components of immersive learning experiences in museums that enhance the depth and breadth of visitor engagement, while guidance and interaction ensure that the educational objectives are

met without stifling individual curiosity. Both cases vary to a large degree in the way in which they integrate these aspects of learning into their design.

Keywords immersive learning; museum education; art education

Introduction

Learning history through extra-muros activities, such as museums, has always been an important part of arts and history education (Burnham and Kai-Kee, 2005). A long tradition exists of scholarship that studies how learning in museums affects learning in history education (Prottas, 2019). Direct contact with authentic artefacts is often seen as one of the major affordances of learning art and history in museums. Bunce (2016) substantiated the assumption that authentic objects increase curiosity and engagement of museum visitors with empirical evidence. Savenije and de Bruijn (2017) found that interplay between cognitive and affective dimensions of history learning in museums stimulated students' ability to engage with the past. This also applies to art-based pedagogy in museums: Chisolm et al. (2020: 736) see the museum as 'a new and creative environment … that is physically distinct from usual teaching settings, offering a potentially stimulating space for students to learn'.

Recently a new generation of technologies has prompted museum education to reconsider the way learning happens (MacDowell and Lock, 2022). Technologies allow multisensory approaches to learning about the past. Technologies such as virtual and augmented reality allow people a sensation of presence in imaginary or distant contexts. These technologies are now increasingly being integrated into museums and exhibitions to foster the museum visit (Camps-Ortueta et al., 2021). Low-tech technologies such as audio tours are used to allow looking at a piece of art or cultural heritage while a voice-over explains or contextualises the object. Also, diverse types of video recordings are used in many museum collections. Immersive experiences combine verbal and visual stimuli in such ways that the line between the real and virtual worlds becomes blurred (Kuhail et al., 2022). Immersive technologies allow the sensation of rare, precious or vulnerable objects or sites that would otherwise not be accessible for a large audience of museum visitors. Hence interaction with objects is not necessarily based only on direct sensorial observation, but also on technological representations (De Freitas et al., 2010). Kyrlitsias et al. (2020), for instance, have shown that a hardly accessible archaeological site can be made accessible through virtual technologies, and thus can serve as a digital learning experience. Camps-Ortueta et al. (2021) report a virtual reality (VR) experience that allows visitors to a natural history museum to combine a visit to the museum with a sensation of walking in a springtime woodland. The nature of these is to a certain extent distinct from the traditional historical sensation in the sense that being in direct contact with museum artefacts is no longer key to the museum experience (Bijsterveld and Van Dijck, 2009). Also, other types of sensorial stimulation now add to learning in museums.

Technological innovations are quickly changing the field of museum education. Empirical research that grounds art and history pedagogies based on these recent innovations is still limited. While previous studies have focused on the technical aspects of immersive museum experiences (H. Lee et al., 2020; Manjrekar et al., 2014), this study explores the educational value of these experiences with a focus on art and history education. Therefore, this study aims to analyse similarities and differences between two cases of immersive experiences in museums.

Theoretical background

In this study, we seek to understand learning in museums with diverse complementary approaches to learning. Museums are often seen as 'not-for-profit, permanent institutions in the service of society that research, collect, conserve, and interpret and exhibit tangible and intangible heritage' (ICOM, 2023: 3). However, there is sometimes a thin line between these non-profit institutions, and commercial exhibits which engage with related activities but still adopt a more limited focus. In this study, both the more traditional and the commercial initiatives are referred to as museums.

We focus on the immersive characteristics of museum experiences. Immersion is defined in diverse ways in research literature. It is not only a state of mind that can be provoked by the narrative content of a novel, but also a property of technological systems (Nilsson et al., 2016). We use immersion

as a property of a system that stimulates human sensation of presence. In general, museums have the benefit of physical immersion (Mystakidis and Lympouridis, 2023): students watch, feel or hear museum objects through direct sensorial stimulation. Museums now increasingly integrate digital technologies with multisensory approaches which enable more complex ways to engage with museum objects. Technologies such as VR, augmented reality (AR) and mixed reality (MR) are then seen as diverse variations of digital immersion (Kuhail et al., 2022; MacDowell and Lock, 2022). There are no clear differences between these types of immersion, yet they can vary in the way they integrate real-world elements. All have in common that they rely at least partially on virtual three-dimensional representations involving interactivity (Merchant et al., 2014). They use technology that interacts with the physical world to create an experience of presence. VR, AR and MR stimulate participants' agency (Makransky and Petersen, 2021), they often use head-mounted displays, controllers or other hand-held devices to stimulate this, yet the use of the term is not limited to these technologies. As a result of this, learning in museums also changes. In a review study, Geerts et al. (2024) conclude that certain tensions exist in the way museum education contributes to student learning, for example, between cognitive and emotional-affective learning goals, and related to disciplinary (historical) and civic educational goals. Multiple theories of learning can be used to understand how audiences engage with learning environments beyond the classroom. These theories of learning have shaped how educators integrate and design experiences to enhance visitors' engagement, knowledge and understanding.

Lave and Wenger's (1991) situated learning theory emphasises that learning occurs through participation in social and cultural activities (see also Anderson et al., 1996). According to proponents of this theory, rich environments are needed to foster learning in context (De Corte et al., 2003). Museums provide such environments: visitors can immerse themselves in authentic artefacts and narratives as museums' knowledge is situated within social and cultural settings. This aspect of learning in museums is often beyond the possibilities of education within general classrooms. Visitors' interactions with exhibits, both narrative content and artefacts, foster learning. Digital immersive experiences allow for more and more complex interactions between visitors and content in museums.

Complementary to this, constructivist theory suggests that learners actively construct their own understanding and knowledge of the world through experiences and reflection (Nordlof, 2014). In the context of museums, this theory emphasises active participation and personal meaning making (Hooper-Greenhill, 2000; Rahm, 2004). According to this theory, learning in museums is stimulated by allowing visitors to engage with exhibits and manipulate objects, and by doing so they construct their own interpretations. Therefore, museums encourage visitors to connect what they see to prior knowledge, making learning more personal and memorable. Moreover, cognitive apprenticeship theory emphasises learning through guided experience and mentorship (Ramdass, 2012). In museum settings, this is relevant when educators or interactive displays model ways of thinking, helping visitors develop expertise in interpreting historical or scientific concepts. Hence, the structure of museum experiences scaffolds learning: for instance, chronological or thematic sequences facilitate comprehension and limit cognitive overload. A combination of structure with open-ended exploration is then supposed to help visitors progressing from novice to more expert understanding (Quintana et al., 2004).

Multimodal theories of learning highlight that people learn through multiple sensory modes. In museums, experiences of immersion can be created through concurrent stimulation of multiple senses. Museums, which offer visual art, interactive exhibits, audio tours and hands-on activities appeal to different ways in which the human brain processes data (Clark and Paivio, 1991). These modes have different affordances, as well as limitations, for making meaning (Kress, 2009). Integration of digital tools and immersive technologies provide different ways of experiencing and understanding content (Pavlović, 2021). Virtual technologies allow people the sensation of presence in imaginary or distant contexts. MR and AR combine real-world objects with digital experiences. Patterson and Han (2019) have shown that the use of VR can foster historical empathy. However, they also add nuances about the idea of direct access to the past, which seems to stand at odds with more complex ways of engaging the past as a construction (P. Lee et al., 1996). Shahab et al. (2023) have evaluated the use of VR in museums and found positive indications regarding engagement, while Kazlauskaitė (2022a) is more reserved about the way in which the past is represented with immersive technology.

Method

This study draws on a comparative case study (Yin, 2014) with two divergent examples of immersive history learning experiences in museums in the Netherlands. It uses content analysis (Elo et al., 2014) to investigate the characteristics of immersive museum experiences for art and history education. An interpretivist research paradigm (Lincoln et al., 2011) is used.

Case selection

The study involves a comparative case analysis (Yin, 2014) of two immersive museum experiences in the Netherlands. Two experiences related to art are chosen, however the implications are not strictly bound to art or art history. In the Netherlands, art, history and art history are not strictly separated disciplines. The teaching and learning of these disciplines are often intertwined with each other. The first case is the Birth House of Mondrian in Amersfoort (the Netherlands). It is operated by a private foundation dedicated to honouring the artist's legacy. This case represents a traditional, biographical museum experience centred on the life and work of Piet Mondrian. The second case, Re-mastered, is a commercial immersive exhibition hosted in Rotterdam, which reinterprets the works of diverse Dutch painters through dynamic animations, sound effects and digital projections. These cases were selected from a larger set of immersive experiences in the Netherlands based on their strongly divergent characteristics. The contrast between the two offers a rich basis for exploring how different immersive approaches may contribute to historical education in museum contexts.

Data collection

Data collection involved field visits to both sites, where the researchers (both authors of this study) engaged in systematic observations. The field visit allowed the researchers to observe exhibits first hand and to reflect on the immersive elements in relation to history education. During these visits, extensive notes were taken on the layout, design and technological features of each experience, as well as on visitor behaviour and engagement. The researchers noted both explicit educational content (such as biographical information in sections of the Mondrian exhibit) and more implicit, experiential aspects (such as the dynamic visual environment of Re-mastered). In addition to this, the websites of both experiences were visited to collect further information.

Data analysis

Data analysis proceeded in two stages. First, detailed descriptions of each case were generated based on field notes and observations, capturing the distinct characteristics of each immersive experience. Then, these descriptions were compared and contrasted using analytic memos (Saldana, 2021), with a focus on identifying the ways in which the two experiences engage with historical themes and how they may contribute to history education. The comparison allowed for reflections on the broader characteristics of immersive museum experiences and their potential to facilitate historical learning.

Reflexivity

Both authors collaborated closely throughout the data collection and analysis phases. As trained educators with backgrounds in primary and secondary history education, we brought a pedagogical perspective to our observations and interpretations. Following each field visit, we engaged in collaborative discussions to interpret our observations and experiences, reflecting on the potential educational value of each museum experience (Olmos-Vega et al., 2023). By triangulating insights, we ensured that interpretations were grounded in our professional expertise and the context of history education (Akkerman et al., 2008).

Findings

Case 1: an immersive exhibition on Mondrian's artistic journey and legacy

Case 1 is organised in three distinct parts, aimed at presenting the life and work of Piet Mondrian through a combination of historical reconstruction and contemporary artistic reinterpretation. The exhibit employs a chronological approach, in which visitors are guided through a fixed sequence of rooms that explore Mondrian's personal and professional evolution, culminating in contemporary artistic impressions inspired by his work. In each room, visitors are free to explore at their own pace and interest, yet textual information, audio guides and explanatory labels structure visitors' attention.

After a short introduction, the first part of the exhibition offers a detailed physical reconstruction of Mondrian's atelier. Visitors are introduced to the artist not only through his artwork but also through a depiction of his personal life. The initial room is designed to familiarise visitors with Mondrian as a person. Short videos are projected on the walls in which the artist is engaged in everyday activities such as smoking or drinking coffee. As such, an experience of AR is created by using audio-visual footage of the artist projected on real-world objects. The intimate glimpses into the artist's life are accompanied by footage of Mondrian at work, emphasising the connection between his personal habits and his creative process. The immersive visuals evoke a sense of the artist's presence, allowing visitors to witness Mondrian's daily routine and artistic practice.

The exhibition then proceeds into a biographical exploration of Mondrian's life, focusing on the cities that played significant roles in shaping his artistic vision. A series of chronological displays highlight key moments in the artist's life in Amersfoort, Amsterdam, Paris and New York. Each city is contextualised with visual and historical documentation, showing how the unique environments of these cities influenced Mondrian's development. Through these displays, visitors gain insight into the interplay between time, space and personal experience in shaping the artist's journey.

In the final phase of the exhibit, two contemporary artists reinterpret Mondrian's legacy by adding another perspective on his body of work. Both create an immersive experience related to the artist's legacy. The first contemporary artist has created a room in which Mondrian's characteristic thick black lines, frequently seen in his paintings, are used to decorate the walls, floor and ceiling, transforming the space into an abstract environment. This spatial interpretation invites visitors to physically step into a visual world reminiscent of Mondrian's iconic style, blurring the line between art and architecture. This AR experience uses the physical environment of the space, in combination with diverse technologies to create an experience of immersion. The second artist employs video projections on a semi-transparent cube, combined with projections on the surrounding walls and floor, and with an auditive soundscape. These projections mix historical footage of Mondrian and his works with contemporary creations. This results in an immersive experience of a virtual artistic universe. The montage juxtaposes Mondrian's historical influence with modern interpretations, creating a layered visual narrative. The combination of past and present in this multimedia assemblage evokes a sensation of being immersed in both Mondrian's historical context and his lasting artistic legacy.

Case 2: an immersive reinterpretation of Dutch painters

The second case is an experience that is mainly centred on one room in which a virtual artistic universe is created. It utilises cutting-edge technology to reimagine and reinterpret the works of Dutch painters from various historical periods. No authentic historical artefacts are used for this purpose. Before entering the main exhibition space, visitors are directed to a waiting area, referred to as 'the playground'. This space is designed as an interactive prelude to the main exhibition. A large LED wall in the waiting room allows visitors to participate in the creative process. Visitors are invited to draw and scan their creations, which are then incorporated into a large-scale, interactive projection. The use of personal artwork fosters a sense of participation and anticipation, engaging visitors in the exhibition even before they enter the first space.

The central part of Case 2 is set in a large room, designed to provide an immersive experience. It integrates dynamic visual and auditory elements, creating a space that draws from both art history and contemporary digital art practices. Cave automatic virtual environment (CAVE) technology is used to create immersion in a virtual world (Grantham O'Brien et al., 2009): the visitor is entirely surrounded by walls on which multiple images are projected. Case 2 is characterised by its minimalist design: naked

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walls devoid of any decorations or art objects. This allows visitors to forget the real world that surrounds them. The walls, floor and ceiling serve as blank canvases for animated projections that reinterpret the works of renowned Dutch artists such as Hieronymus Bosch, Pieter Bruegel, Johannes Vermeer, Vincent van Gogh and Piet Mondrian. These animations do not offer faithful reproductions of the original paintings; rather, they suggest a 'living world' experience, where elements of the paintings move and transform dynamically, immersing visitors in an animated environment. This 'reimagining' of historical paintings intends to allow visitors to reflect upon the essence and themes of each artist's work in a novel and fluid manner.

As visitors walk around the room, they are engulfed by ever-changing visuals on all walls and on the floor, creating a 360-degree sensory experience. Due to the concurrent changes across multiple surfaces, it is impossible for visitors to view the entirety of the projections at once, encouraging exploration and a sense of wonder. Notably, the exhibition does not include traditional museum features such as textual information, audio guides or explanatory labels. Instead, the experience is accompanied by a soundscape of electronic music created by a contemporary Dutch DJ, which amplifies the sense of entering a magical, dreamlike world. The absence of text emphasises the non-verbal and emotional engagement with the art, encouraging visitors to experience the exhibition as a holistic sensory experience, free from preconceived interpretations or historical context.

Cross-case aspects of immersive museum experiences

The comparison of two immersive learning museum cases provides an insightful exploration of how immersion can vary in characteristics, especially when juxtaposed with more traditional museum visits. Both cases offer distinct approaches to integrating digital immersive experiences in museum learning, each with its own way of engaging visitors and creating immersion. Both cases demonstrate contrasting approaches to engaging with art and the past. In Case 1, the biographical rooms of the museum follow a traditional display format, where visitors can easily differentiate between authentic historical objects and technological add-ons. For instance, historical pictures of the artist's atelier help interpret the physical reconstruction in the museum; an audio tour also serves this purpose. However, in the final rooms, which offer an artistic interpretation of Mondrian's work, this distinction between past and present becomes blurred. Case 2 represents a more rudimentary approach to interpreting the past. The museum's website states that its aim is to 'reimagine the Old Dutch Masters by the New Dutch Masters'. The exhibition, however, does not specify precisely who are seen as old or new Dutch masters. For visitors, the specific historical elements of the paintings, and the ways in which they have been adapted or transformed by contemporary artists, remain untransparent. Immersion is pre-eminently non-rational here: it stimulates fantasy and engagement.

In Case 1, content is presented in structured form, guided by a proposed sequence of rooms that, while flexible, offers a path designed to foster gradual understanding of the artist and his work. The ability for visitors to deviate from this suggested path allows for a degree of autonomy and exploration, yet the structure provides a layer of scaffolding that facilitates a deeper connection with the material. An audio tour, which contextualises the artist's biography and work, further enhances this guided and structured immersion by directing attention to specific aspects of the exhibit, ensuring that visitors have a focused and educational experience. The level of immersion in Case 1, while structured, allows for personal pacing and selective engagement with the exhibition, creating a hybrid between structured and open-ended exploration. It combines structured guidance with opportunities for individual choice. The proposed sequence of rooms and the audio tour act as guiding tools that help visitors navigate the exhibition, ensuring a logical progression through the artist's life and work. However, within this framework, visitors are free to linger on certain objects, spend more or less time in particular rooms, or even skip parts of the exhibition altogether. This blend of guidance and personal freedom allows for a learning experience that is immersive yet pedagogically structured, making it suitable for visitors seeking both educational depth and autonomy.

In contrast, Case 2 creates a less structured, fully open-ended exploration. Visitors are not provided with a guiding narrative. Instead, the experience is centred on technology-driven adaptations of famous Dutch paintings, where digital enhancements, such as moving images and soundscapes, invite visitors into a more imaginative and less prescriptive experience. Without the scaffolding of an audio tour or guided path, visitors in Case 2 engage with the exhibition in a more self-directed manner, navigating through a world shaped by artistic interpretations rather than historical context. Without an imposed

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sequence or a narrative voice guiding the experience, visitors are left to explore the digital adaptations of paintings at their own pace and in their own way. The immersion here is more imaginative and abstract, relying heavily on digital technology to blur the boundaries between static art and dynamic experience.

Another significant point of comparison between the two cases is the role of authentic artefacts in the immersive experience. Case 1 uses AR to create a combination of real-world objects with digital animations. This incorporates historical objects, such as items from the artist's atelier, photographs, newspaper clippings and advertising posters. These authentic objects play a crucial role in creating historical and biographical immersion, prompting visitors to perceive a sense of connection to the artist's life and the time in which he worked. The presence of these real-world objects anchors the immersive experience in a tangible reality, making the exhibition feel more grounded and historically rich. In contrast, Case 2 does not integrate any authentic artefacts. Instead, the experience relies on digitised and adapted versions of famous Dutch paintings, transformed through technology into moving images with accompanying soundscapes. The absence of physical artefacts shifts the focus from historical immersion to a more imaginative, artistic one. Visitors are not engaging with the real-world objects related to the artists or their time; instead, they are immersed in a digital recreation of the artwork that invites them to interpret and experience the paintings in a new way.

Both cases utilise multisensory elements to enhance immersion, although in different ways. Case 1 employs a combination of written text, images and audio to project historical context on to both authentic artefacts and replicas. The audio tour helps visitors process the information and place the objects in a biographical and historical framework. While immersive, this approach remains closer to traditional museum experiences in its reliance on real-world objects and linear storytelling. In Case 2, VR is created with a combination of sound and images. Here, immersion is exclusively reliant on technology, with sound and moving images transforming static paintings into dynamic experiences. This use of multisensory modes creates an immersive environment that is more abstract and fantastical, encouraging visitors to engage emotionally and imaginatively with the artwork.

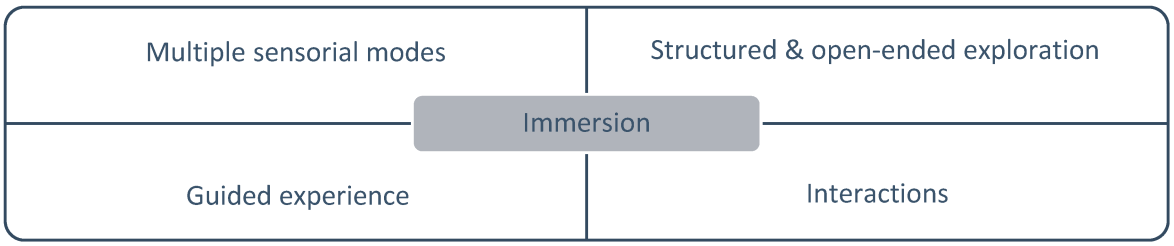
Discussion and conclusion

The two cases examined in this study elucidate the multifaceted nature in which museums shape visitor engagement with historical and art historical content. Immersion, once a straightforward aspect of museum learning, is now redefined through technological advancements that offer varying scales and characteristics of engagement. In addition to physical sensations that stimulate visitors to observe the presence of historical or artistic objects, now digital sensorial stimuli are used. Case 2 promotes itself as an experience in which visitors 'reimagine Dutch art'. In a way, not only Case 2, but both cases allow visitors to reimagine traditional art. Both provide multisensorial stimuli in which iconic artistic work is 'reimagined' while visitors are immersed in a varying combination of direct experience of artefacts with technological sensations. Drawing on these cases, we posit the construct of an immersive learning experience (ILE): this is a setting in which digital or physical stimuli provide learners with a multisensorial sensation that allows them to imagine a more or less accurate representation of art and history. Figure 1 summarises several design characteristics of ILE in museums. Interaction and multimodality emerge as critical components that enhance the depth and breadth of visitor engagement, while guidance and interaction ensure that educational objectives are met without stifling individual curiosity. Both cases vary to a large degree in the way in which they integrate these aspects of learning into their design. This can be at least partially explained by the fact that Case 1 is a traditional museum serving the purpose of conserving, showcasing and interpreting heritage, while Case 2 is an example of a commercial exhibit which *stricto sensu* does not fit the traditional definition of what museums do.

In line with existing research literature in the field (Geerts et al., 2024; Patterson and Han, 2019), deliberate integration of these parameters within the design of the museum is expected to impact the effectiveness of learning outcomes. Educators should resist temptations to be blinded by the technological innovation of immersive museum experiences. To paraphrase Kazlauskaitė (2022b): seeing is not knowing, the learning effects of VR are not only shaped by its content representation. Rather, determining both the extent and the nature of students' learning in immersive learning experiences in museums seems an overly complex endeavour. The first case in this study exemplifies a balanced approach, where structured guidance and authentic interactions with historical artefacts coexist with opportunities for personal exploration, thereby facilitating a nuanced understanding of the subject

matter. Conversely, the second case highlights a more experimental application of technology, prioritising imaginative and sensory experiences over traditional educational scaffolding. However, as this study focuses on the physical and digital characteristics of museum settings, the psychological characteristics of learning in these settings remained out of scope. Future research should help determine how visitors engage with ILEs of diverse nature, and consequently their usefulness for art and history education.

Figure 1. Design characteristics of ILE in museum contexts



Despite the considerable variety of possible immersive experiences in museums, this study increases our understanding of what ILEs in museums are (MacDowell and Lock, 2022). ILEs in museums are grounded in interaction with artefacts, although these are not necessarily original or authentic artefacts. Multiple sensorial modes are used to stimulate this. They are to a certain extent structured, but meanwhile open-ended, which allows for exploration to occur. Diverse options exist to facilitate guidance and cognitive apprenticeship in immersive learning experiences. Moreover, the design characteristics of immersive learning experiences emphasise that the strategic alignment of immersion, interaction, multimodality and guidance is essential for optimising educational experiences. The cases under study do not consider all these characteristics. As museums continue to adopt and adapt new technologies, it is necessary to consider how design aspects can be harmoniously blended to support learning in diverse contexts and for diverse objectives.

Data and materials availability statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations and conflicts of interest

Research ethics statement

Not applicable to this article.

Consent for publication statement

Not applicable to this article.

Conflicts of interest statement

The authors declare no conflicts of interest with this work. All efforts to sufficiently anonymise the authors during peer review of this article have been made. The authors declare no further conflicts with this article.

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