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Digital Storytelling approaches in Virtual Museums: Umbrella review of systematic reviews

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Abstract
Museums have the mission of promoting and safeguarding objects of historical value and have undergone several modifications over time to take the focus off the object and give more importance to information and the visitor. Currently they encompass different types of experiences, either through digital and interactive elements, or through new approaches, such as storytelling, which has acted as a protagonist of these transformations. In this sense, the museum in the digital mode, known as virtual museum, plays an important role in this sharing of information and experiences. However, by having different modalities for navigation and interaction, especially in formats that simulate the physical visit, like virtual tours, they present some problems that have been identified in the literature, such as, solitary visit, lack of script to follow and little interaction with the exhibited objects.
This literature review was conducted between 2013-2021 and 14 papers were selected for analysis. The results support the understanding of the role of narratives and the way museums use them in the virtual space and highlights the gaps of knowledge on the use of storytelling in this context.

Keywords *Virtual Museum, Virtual Tour, Digital Storytelling, Interactive Museum*

1. Introduction

Museums, while primarily dedicated to collecting and studying objects, have undergone numerous changes (Keene, 1998). And yet, except when the physical space itself is an essential part of the content, as in biographical museums (Albano, 2007), objects continue to be their greatest asset, imbued with meaning.

With the popularisation of the Internet, museums began to offer the public different possibilities for interaction and experience (Cádima, 1999). Thus emerged the concept of Virtual Museum, also described as Cybermuseum; Webmuseum; Digital Museum; Online Museum; Electronic Museum, or Hypermuseum (Magaldi, 2010). Examples involve museums such as The British Museum and the Louvre, placing information on the Web page or making pre-recorded scripts available through mobile devices (Schweibenz, 2019).

Bowen (1995) mentions the museum community's concern that virtual museums could replace the physical museum, but now that we have a large presence of museums on the web, this issue has been overcome. Currently, there is consensus on the complementary important relationship of the two types of visits (Marty, 2007).

Schweibenz (2004) classified museums according to their Internet presence into three types: Brochure Museum, providing information to future visitors; Content Museum, centred on presenting details of works and collections (more appropriate for experts than laymen); and Learning Museum, with didactically enhanced information. The websites of some large museums have such characteristics, but it is up to each museum to decide what content to make available. In general, they present access information, schedules, ticket sales, and some present part of their digitised collections with authoring information, timelines, educational resources, etc.

Povroznik (2018) describes a virtual museum as an information system that comprises a set of collections of objects (items), enriched with metadata, experienced in a digital space. Some museums also provide virtual tours, popularised by the Google Arts and Culture project (Zhao et al., 2015). These virtual experiences usually present 360-degree panoramic images that allow moving between ground hotspots and through tags, increasing the visitors' experience with pop-up windows providing descriptions, narrations, videos, and other content (Resta et al., 2021). One of the challenges of this is to create exhibition practices that provide multisensory contexts and experiences (ibid.). Although most users agree that virtual museums are useful and easy to use (Lusa et al., 2020), virtual tour visits have no defined objective, serving only to simulate the museum environment, and few objects have additional information, which makes the visit quite monotonous (Lopez Rodriguez, 2020).

Kersten et al., (2017) points out that a virtual environment or virtual reality application undeniably offers a good response in terms of immersion and engagement, because it differs from other traditional forms of visualization (Setiawan et al., 2020): from a behavioural point of view but also from a physical-neurological point of view (Škola et al., 2020). In this sense, mixed approach applications that use digital artifacts in physical environments, such as Augmented Reality (AR), have been increasingly explored to improve the visitor experience (Kristensen et al., 2021), due to not excluding sensations inherent to a physical visit. According to Oliveira et al., (2021), 68.2% of museums using this approach achieved satisfactory results regarding feelings of immersion and interaction, which made them more attractive. Furthermore, as artefacts do not need to be exposed, being 3D models, they can be visualised in different places and contexts, as well as incorporating audio, video, and text elements.

In addition to browsing content on a web page, a virtual museum, or a virtual visit to a museum, can be understood as an interactive visit with a 360-degree view of physical spaces. However, for this approach some problems were identified in the literature (NEMO, 2020) such as low level of freedom in navigation; lonely experience; lack of a script to follow, and lack of interaction with exhibited objects.

Although virtual tours have been widely used in museums as an alternative to physical visits, especially with the Google Arts and Culture project, many museums such as the Louvre Museum or the Vatican Museum have discontinued updating their contents in this modality and others depend on the updating of the photographic mapping made by Google. All these cases are examples of the afore-mentioned problems.

With this review we discuss these problems and present possible solutions through the storytelling approach. Different approaches to storytelling in virtual museums are presented to understand their role, how they are used and how they can help in this process.

The paper is organized as follows. First, the literature review process is described, followed by an overview of the search process and the findings (Section 3). Next, the data procedures are presented (Section 4) followed by a discussion of the key findings (Section 5). Finally, the conclusions, with recommendations for future research, are presented, along with their implications (Section 6).

2. Background

In this section we present the experience of visiting museums that use technologies as a fundamental part of their operation; we also present the concept of virtual museum and virtual tour in the light of navigation and interactivity modalities with a storytelling approach.

2.1. Museums and interactive technology

Museum as a place of inspiration and stimulation of artistic and intellectual creativity date back to the IV century (Jalal & Abdulsalam, 2020), but only in the XVIII century did the term begin to designate a space of scientific preservation.

The International Council of Museums (ICOM) defines a museum as:

> *"A museum is a non-profit, permanent institution in the service of society and its development, open to the public, which acquires, conserves, researches, communicates and exhibits the tangible and intangible heritage of humanity and its environment for the purposes of education, study and enjoyment"* (ICOM, 2021).

According to UNESCO, in the last 40 years the number of museums has increased from 22,000 to over 95,000 worldwide (UNESCO, 2021). Attracting and motivating the public is part of the communication and marketing strategies a museum needs to adopt (Pirolo & Nasta, 2021).

The communication generally used by museums is based on ticket sales or guidance on where to begin the visit. Many offer graphic materials such as leaflets, others have audio guides that can be rented. In general, the visitor seeks information to understand the exhibition (Su & Teng, 2018).

Regardless of whether the visit is guided by a professional or an audio guide, it is based on an idealised itinerary (even if the visitor chooses not to follow it), and information is commonly explanations of the works, artists, and contexts.

When the visit is autonomous, without auxiliary resources, the experience will depend on expectations, interests, and previous knowledge of everyone: each visitor will face objects differently, drawing their conclusions according to their personal experience (Tallon & Walker, 2008).

Regarding lack of interest in museums, especially by young audiences, it is usually due to issues of how visits happen (Cesário, 2017). Even if some museums have a budget for interaction technologies, most present their exhibited objects in showcases with brief captions and direct visitors to predetermined paths (Dal Falco, 2017). All newsworthy technology is plausible in big museums, but in small museums the most common situation is lack of the necessary skills and resources to make these spaces digital, which are heavily dependent on local government grants (Evrard & Krebs, 2018).

Some exhibitions combine different types of technology and promote pleasant interactive experiences, offering visual and tactile stimuli. But although they address various fields of science, arts, and other themes commonly found in museums, these exhibitions are not necessarily promoted by museums. This is the case of cultural institutions or thematic traveling exhibitions promoted by specialized companies where there is normally no exhibition of original works. Works of art, artists or artistic movements serve only as inspiration for the creation of diverse experiences and in different media. In the exhibition Meet Vincent Van Gogh that tells the story of the painter and presents some of his works of art in an interactive way, one of the attractions is a large canvas that is "painted" by visitors with the brushstroke technique used by Van Gogh (Figure 1).

Figure 1: Interactive exhibition "Meet Vincent Van Gogh", Lisbon, Portugal 2020. https://lulimonteleone.com/meet-vincent-van-gogh/. Accessed 12/12/2022

In museums, in addition to the mission of safeguarding the collection, there are concerns with social and cultural issues of its location, and with stimulating critical thinking of the public and increasing the number of culturally active citizens (Oliveira, 2013).

2.2 Virtual museums and virtual tours

A Virtual Museum is not transporting the physical museum to the Web, because there is not a total transposition of the museum, but rather parts of interest. It also is not an archive, database, or electronic complement of the museum (Antinucci, 2007).

From the 1930s with the preview of the future of a possible telemuseum with images of galleries transmitted by air (Kiesler, 1930) to the beginning of its realisation around the 1970s (Schweibenz, 2019; Djindjian, 2007), this approach was designed to be something to an archive, with detailed and catalogued information, rather than a space for sensory experimentation.

The virtual tour emerged along the lines of 3D visualizations provided by "first-person shooter" video games (Schneider, 2004), simulating the user's perspective, responding to external computational devices to change the spatial perspective. Some museums offer this virtual tour in their virtual spaces, with interaction through 360-degree images. Its limitations include the low level of navigational freedom, the lonely experience (as if the museum was closed and one was the only visitor), the lack of a guiding

script or objective, the lack of interaction with objects, which sometimes exists as separate media elements (Perry et al., 2017; Kabassi et al., 2019). Figure 2 shows a screenshot of the virtual tour (2020) of the Vatican Museum, where the visitor is alone, without instructions on what to do and without possibility of interaction with objects on display.

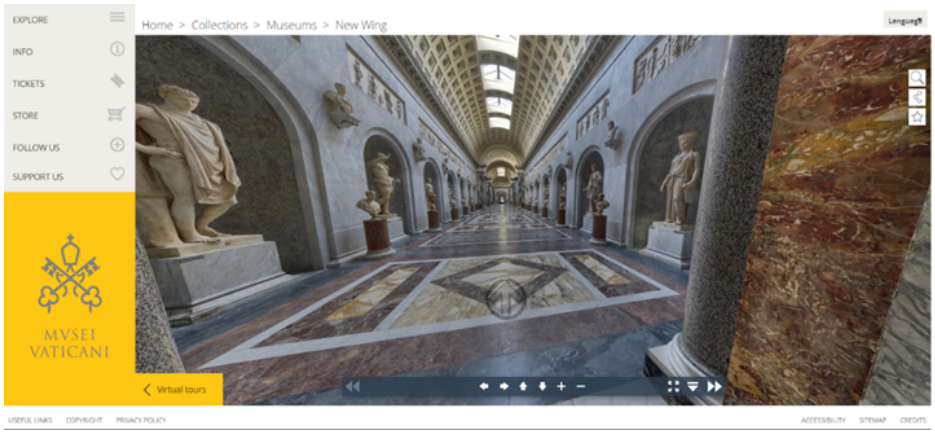

Figure 2: Virtual tour of the Vatican Museum. Official Vatican website: https://www.museivaticani.va/content/museivaticani/en/collezioni/musei/braccio-nuovo/tour-virtuale.html. Accessed: 09/05/2022

The current model of a virtual tour is based on two aspects according to Resta et al., (2021), shown in Figure 3:

1 - **Navigate**: browsing the website to search for information/view collections;

2 - **Interaction** through website navigation, e.g., in 360-degree virtual tour mode.

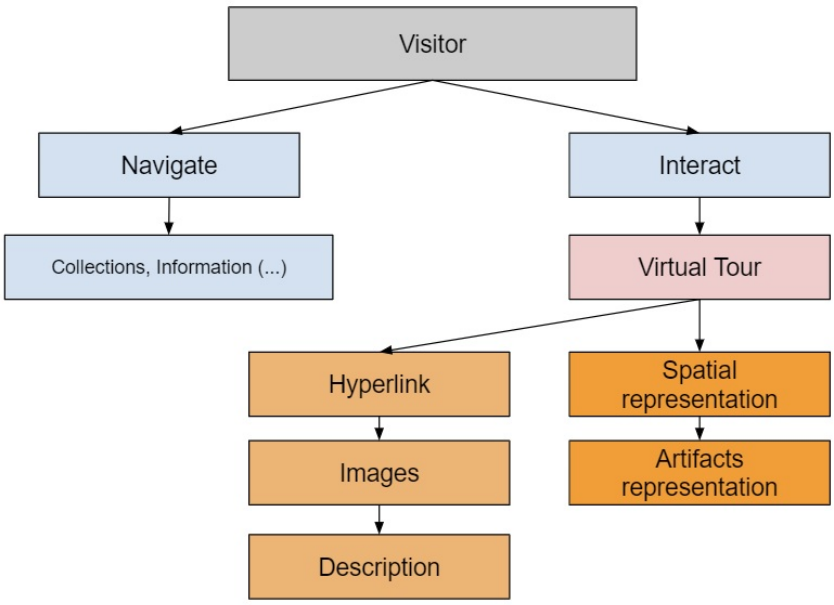

Figure 3: Structure of virtual tours (adapted from Resta et al., 2021).

This virtual tour model, part of the Resta et al., (2021) framework, appears on the museums' websites independently of their content, and in some cases, in competition with the rest of the website content. The visitor looking for information about the museum or specific works may not be able to easily discover the virtual tour option, and those looking specifically for a virtual tour usually consider other means of research and are directed to a specific museum link with this modality and end up not finding any connection with the works and information, largely due to usability problems (Macdonald, 2015).

In the physical visit, the technological artefacts (interactive displays, projections, audios, etc.) indicate the route, but they also rely heavily on staff to provide explanations.

Rahim et al., (2017) point out that contrary to what happens when visiting the physical museum, visitors in the virtual museum do not receive the necessary attention to make a satisfactory visit.

According to the Network Of European Museum Organisations - NEMO (2020), online museums are important extensions and complements of physical museums, but lack a solid evaluation of online visits. Rahim et al., (2017) also emphasise that the narrative elements need to be clear to guide visitors and that this is still a weak point of this approach. Argyriou et al., (2020) studied users of virtual tours in a controlled environment, regarding immersion, navigation, and engagement, and found that:

- Most visitors would like assistance rather than exploring the environment without a defined objective;
- Most visitors created their own route following arrows;
- The feeling of total involvement was mentioned by less than half of the participants;
- Only half of the participants felt excited about the experience;
- Only half of the participants felt in control of the experience.

Therefore, the following problems emerged:

1. Low level of freedom in navigation;
2. Lonely experience;
3. Lack of a script to follow;
4. Lack of interaction with exhibited objects.

2.3 Digital storytelling

A story is a synthesis of heterogeneous elements to present a fact, over three stages: beginning, middle, and end. Each phase contributes to its whole design. This is the basis of the narrative, structured and organised ideas linking events (Villaseñor, 2007). This structure presents actions or experiences that in turn are composed of smaller ones. It is a changeable cultural artefact although the purpose remains indelible: the telling a story (Bamberg, M., 2012).

Usually, the narrative develops in a temporal movement, or in another socio-culturally recognizable way (Squire, 2014) verbal or written, and can take very varied forms, from gestures and symbols (Carr, 1991) to combination of resources and technology. From the first pictorial records of man's communication, through the oral and written traditions of antiquity to the present day, the fluid nature of narrative and its adaptation throughout history can be clearly seen. In the 1990s, Lambert (Lambert, 2013) coined the term Digital Storytelling, originally thought of as a way of combining narrative with audio and video content, and currently being widely exploited by museums and cultural institutions in varied media to provide interactive experiences, because of its great impact on interaction with content (Floch & Jiang, 2015).

Operationally, digital storytelling does not need to be a sophisticated technological process, as the focus is not the technical aspect, but rather the combination of multimedia elements to tell the stories (Martin et al., 2019). The inclusion of new technologies in the narrative process is not only aimed at providing the sensation of immersion in the story: a book also has this capacity. Rather new tech aims to offer the possibility of controlling elements such as characters and actions and even influence the course of the story through their decisions (Mulholland & Collins, 2002).

Robin (2006) divided digital narratives into three categories: personal narratives, historical documentaries, and stories that inform or instruct. Personal narratives are views of the facts from the author's point of view, and therefore quite used in direct dialogues of interactive museum systems, where the main character is the narrator interacting with visitors, presenting the history of objects or asking them to make choices. Historical documentaries examine significant past events and seek to explain them. The category of stories that inform or instruct is possibly the most common in museums, being associated with the presentation of objects' details without a narrator.

In virtual museums, storytelling allows different narratives to be supported considering elements such as maps, 3D, timelines, images, sound, etc. Casparini (2017), regardless of being in online catalogue format or with interactive elements. For framing purposes, all mentions of storytelling (ST) in this document will be equivalent to Digital Storytelling.

Given the characteristics of storytelling and its adaptability to the different applications of museums, we believe this approach is potentially capable of minimizing the problems identified.
Therefore, the main contribution of this research is to identify uses of digital storytelling in virtual museums.

3. Survey methodology and criteria

In this section, we describe the methodology of this systematic umbrella review and the search criteria.

3.1 Concept

For scope, virtual museums were considered not only as entirely digital museums, i.e., visited only through the Internet, but also those where the physical visit experience depends on technological artefacts to superimpose virtual elements on physical objects or to interact with them.

3.2 Search process

Exploratory search was conducted to identify relevant cases in this field using the (de Lima et al., 2021) method, that starts from the definition of the problem and the contributions in the area to design the scenarios and the evaluation criteria. We searched for keywords and variations, such as: "storytelling", "virtual museum", "Virtual Tour" and "Tour 360". From the results, we selected a corpus of 15 articles, published between 2013 and 2021 in journals from ACM, IEEE, Springer, & Taylor & Francis, which are major scholarship publishers with indexed journals in the fields of information technology and multimedia, hence selected as a relevant sample for the exploratory stage. We elected not to include conference proceedings in this stage, given that the journal article sampling yielded a rich enough number of articles for this exploratory stage. Book chapters were not considered, since their publication process does not guarantee a peer review process and would have to be checked on a consuming case-per-base basis. (Conference proceedings and journals from other sources were included in the subsequent iteration, as described further ahead.) For this analysis, our inclusion criteria specified that an article would only be included for further analysis if the topic addressed storytelling in museums in the virtual mode. These articles were the most relevant in this perspective. In this exploratory corpus, the term "virtual museum" pointed to "3D" and "Virtual Reality" as an integral part of the universe of virtual museums, alongside other themes such as "education" and "serious games". For "storytelling", this exploratory search pointed to areas such as health, sports, journalism, marketing, tourism, and education. For better mapping of areas of convergence, we identified "Narrative", "Technology", and "Historical Heritage" as encompassing variations of the seed keywords.

Following the exploratory search, a second search iteration focused on finding literature reviews in the overall peer-reviewed literature. This was done by combining the outcome of keywords from the exploratory search phase, using the following procedure: Title words: ("systematic review" OR "mapping review" OR "mapping study") and in the keywords, the combination of terms identified in the exploratory search, divided by categories.

Search 1: Keywords related to virtual museums
keywords: ("virtual museum" OR "virtual museums" OR "e-museum" OR "e-museums")

Search 2: keywords related to the field of museum studies
keywords: ("cibermuseology" OR "cybermuseology" OR "cybermuseum" OR "cybermusem" OR "cyber-museology" OR "cyber-museum" OR "cyber-museum" OR "cyber-museum")

Search 3: Keywords related to different virtual museums approaches
keywords: ("telemuseum" OR "electronic museum" OR "tele-museum" OR "web museum" OR "3D museum" OR "online museum" OR "online museums")

Search 4: Keywords related to heritage
keywords: ("digital heritage" OR "virtual heritage")

Search 5: Keywords related to storytelling
keywords: ("storytelling" OR "story" OR "stories" OR "digital storytelling" OR "digital narrative" OR "interactive story")

After analysing the results and excluding duplicates, another search was carried out with the combination of the main terms of the keyword groups.

Search 6: Combination of "game" and "museum"
Title words:("systematic review" OR "cartographic review" OR "cartographic study") AND (game OR games OR gamification)
keywords: "museum" OR "museum"

Search 7: Combining "game" and "museum" in virtual modality
Title words: ("systematic review" OR "cartographic review" OR "cartographic study") AND (game OR games OR gamification)
Keywords: ("virtual museum" OR "virtual museums" OR "e-museum" OR "e-museums")

Search 8: Combining "virtual museum" with "storytelling"
Title words: ("systematic review" OR "cartographic review" OR "cartographic study")
keywords: "virtual museum" and "storytelling

Search 9: Combining "storytelling" and "museum"
Title words: ("systematic review" OR "cartographic review" OR "cartographic study")
Keywords: ("digital narrative" OR "interactive storytelling" OR "storytelling") AND ("museum" OR "museums")

The searches were carried out between October 2021 and March 2022 and performed on Google Scholar solely, given its solid coverage of the academic literature in comparison with other referencing sources (Martín-Martín, A. et al., 2021). We used the Publish or Perish application (Harzing, 2007) to retrieve results in spreadsheet form. Only English-language results were selected.

This search yielded n=59 potentially relevant articles. The subsequent criteria were: 1 - must be literature reviews; 2 - must employ the search terms within their focus. After analysing the titles, 4 were found to be duplicates and excluded. By reading abstracts and the entire text for adequacy, 34 articles were also excluded (for instance the terms were found only in the list of references). The remaining 21 articles were analysed regarding the context of the search terms and the relevance of their focus. We excluded 7 articles without significant survey contributions to digital storytelling in virtual museums. After this analysis, 14 articles formed the final corpus (figure 4).

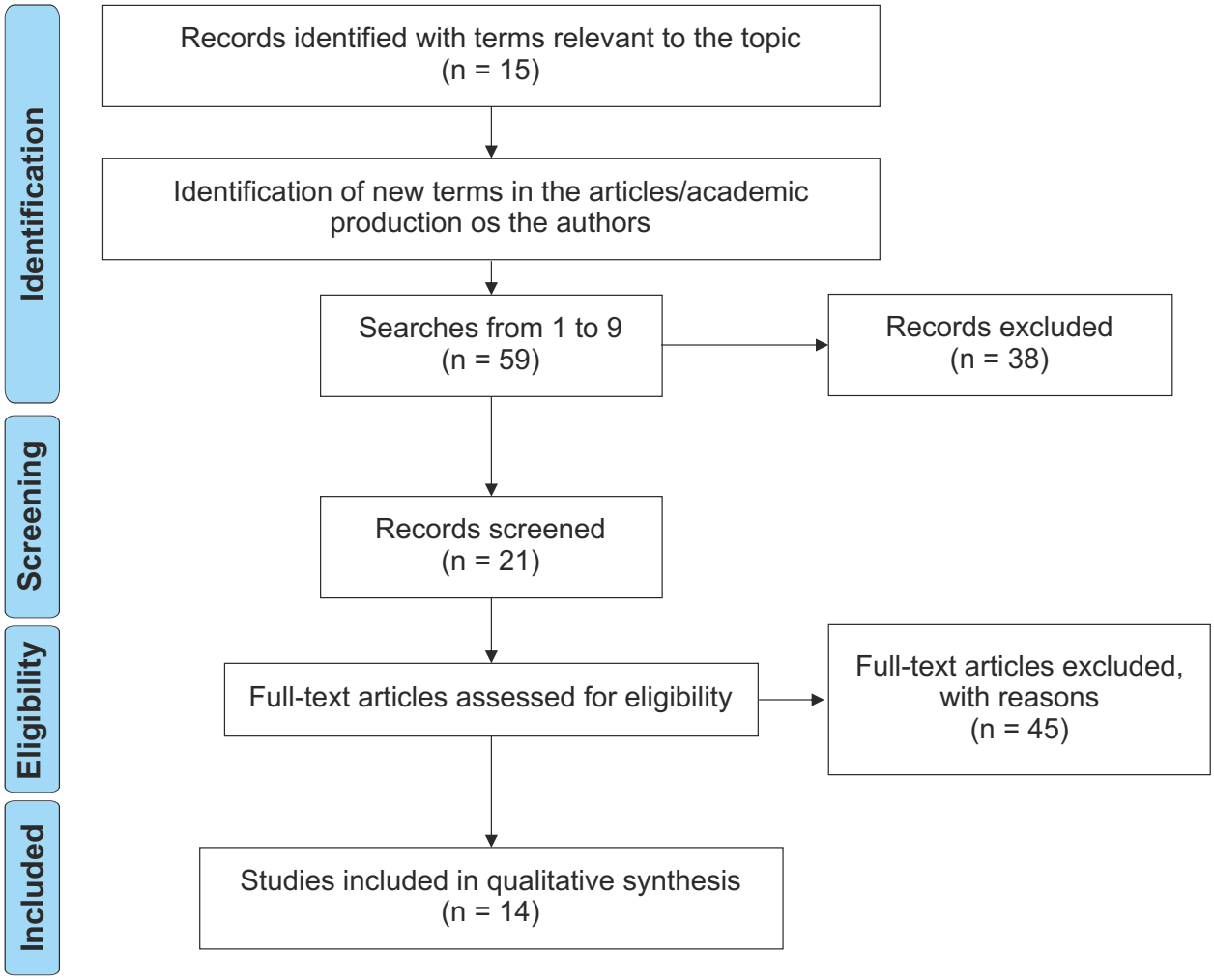

Figure 4: Systematic review flow chart of the process described in section 3.2.

The complete list of the 14 corpus articles is shown in Table 1.

Table 1: Dataset of papers resulting from the search process.

ID	Year	Author	Title
ID1	2022	Melro, et al.	Role of Gamification in Cultural Heritage Dissemination: A Systematic Review
ID2	2021	Rodriguez, et al.	Digital Storytelling in Education: A Systematic Review of the Literature
ID3	2021	De La Paz Diulio, et al.	Usability of data-oriented user interfaces for cultural heritage: A systematic mapping study
ID4	2021	Pasca, et al.	Gamification in tourism and hospitality research in the era of digital platforms: a systematic literature review
ID5	2021	Chong, et al.	Comprehensive systematic review on virtual reality for cultural heritage practices: coherent taxonomy and motivations

ID6	2021	Nowacki, M.	Heritage Interpretation and Sustainable Development: A Systematic Literature Review
ID7	2020	Junaini et al.	Designing augmented reality tools for enhancing art gallery and museum visitors experience: a systematic review of current trends.
ID8	2020	Ayala et al.	Examining the state of the art of audience development in museums and heritage organizations: a Systematic Literature review
ID9	2019	Pellas et al.	A systematic literature review of mixed reality environments in K-12 education
ID10	2019	Yomeldi et al.	Serious Game on Mobile Learning: A Systematic Literature Review
ID11	2019	Karageorgiou et al.	Smart Escape Rooms for Cultural Heritage: A Systematic Review
ID12	2018	Laine, T.	Mobile educational augmented reality games: a systematic literature review and two case studies
ID13	2018	Cárdenas-Robledo & Peña-Ayala	Ubiquitous learning: A systematic review
ID14	2016	Paliokas & Sylaiou	The use of serious games in museum visits and exhibitions: A systematic mapping study

4. Data procedures

We performed qualitative element extraction and thematic analysis following the process by Vaismoradi et al. (Vaismoradi et al., 2016): extraction of excerpts with the main ideas of the problem, and their analysis to generate codes that share common points. These codes are reinterpreted to create themes at different levels, which form a final set of themes able to translate the ideas of the problem.

All articles were read in full by the authors to extract potentially relevant excerpts for an overview of the subject. The first author initially read and extracted from papers 1-5 and this process was then analysed and corrected by the remaining authors. The process was then repeated for papers 6-10, which stabilized the extraction quality. The first author then extracted the excerpts for papers 11-14. Excerpts were normalised to highlight the most relevant aspects, as in this example:

> *"The development of MR environments based on the reviewed studies inevitably varied, since many of them encompassed the narrative aspect of creating interactive-multimedia applications to support problem-solving tasks related to formal scientific fields (e.g., Chao et al., 2016; de Lima et al. 2014) or informal instructional settings, in museums (Bayon et al. 2003; Rowe 2014; Yoon et al. 2012)"*

Was extracted as:

> *"(...) many of (...) [the reviewed studies] encompassed the narrative aspect of creating interactive-multimedia applications (...) [in] informal instructional settings, in museums."*

From the 14 corpus articles 32 excerpts were extracted. This normalisation was also done by the same refinement process between the first authors and the remaining authors, similarly to the extraction process.

4.1. Thematic analysis

In this step excerpts were synthesised into themes, interpreting and categorising the main concept. For example, in ID7, the excerpt "*Thus, it is necessary to comprehend why AR is the best to augment narration and storytelling about the museums*' artifacts" was synthesised as "*AR as a way to increase storytelling about artifacts*". To categorise this information, we discarded the technology used (in this case, AR) retaining only the central idea of uses of digital storytelling in virtual museums. This was transformed into a code, "*tell stories about artifacts*". This decoupage process was necessary to extract codes capable of translating the main idea of the excerpts. At the end of this stage, 34 codes were identified.

As per the (Vaismoradi et al., 2016) process, we sought codes that converged to the same meaning, and fused them into a single code with the core idea. These codes formed an initial list of themes (level 1 themes). Each level 1 theme was defined according to the object of study. From analysis of these definitions for convergence and consistency, new (level 2) themes were created. Table 2 presents the list with the final themes, their number of related codes, and their descriptions.

Table 2: List of ending themes created from the synthesis of excerpts.

Theme	No. codes	Prevalence	Description
1. Provide deeper knowledge about content	6	18%	This theme aggregates ways of using ST to provide a deeper understanding of museum content, whether through descriptions or highlighting points of interest, or by connecting objects from different museums depending on their meaning, or through the interaction provided by characters.
2. Informal exposure	2	6%	This theme aggregates ways of using ST only to present museum content, in an informal way, whether interactive or not, regardless of the technical devices used (mobile, fixed, etc.).
3. Educational serious games	11	33%	This theme aggregates ways of using ST by employing educational serious games. They are usually used to present museum objects and spaces for learning purposes, even if details are often missing.
4. Modify the experience	6	18%	This theme aggregates ways of using ST to modify the visiting experience by adapting to new formats and approaches (e.g., entertainment or experiments in museums other than traditional ones).

5. Engagement	4	12%	This theme aggregates ways of using ST to provide external public engagement, including tourism promotion and media communication.
6. Reinterpret	1	3%	This theme aggregates ways of using ST in museums to provide a new interpretation of something, for example by contrasting the current artefact with its state at the original time, thus altering the visitor's personal perspective on the objects.
7. Generic virtual museums	1	3%	This theme aggregates ways of using ST in virtual museums that focus on the spatial organisation of the contents as if it were a physical museum.
8. Generic digital storytelling	2	6%	This theme aggregates references to the use of ST, interactive or not, without concrete details on how or for what.

5. Results and Discussion

In this section, we reflect on the results of the searches and discuss the themes generated.

5.1 Theme 1: Provide deeper knowledge about content

This theme aggregates ways of using ST to provide a more detailed and in-depth understanding of museum content. For example, linking stories to points of interest in the museum:

> *"(...) uses the (...) offers a model in which storytelling features augment the content in Points of Interest.". (Paper ID1)"*

Or even using these stories to link objects in different museums:

> *"(...) interconnects [between museums] venues, objects and stories to increase learnability in museums" (Paper ID3)*

Or even using ST to recommend content to visitors depending on their profile, to provide that deeper understanding:

> *"(...) a new methodology (...) that recommends content for a specific visitor profile to enrich the creation of stories related to museum objects." (Paper ID2)*

5.2 Theme 2: Informal exposure

This theme aggregates ways of using ST only to present museum content informally, without being linked to any educational or instructional activity.

All informal forms of use are classified in this theme, whether interactive or not, whether they use technological equipment or not. Also, the type of technical device (mobile, fixed, etc.) is indifferent. For example:

> *"(...) language u-learning in socio-cultural contexts to discover that many museums adopted ubiquitous location-based systems using mobile devices to strengthen social ties (...)" (Paper ID13)*

Included in this theme are forms of ST use without instructional intent that have other intentions of supporting specific visitors, without however being linked to some broader strategy, for example:

> *"Storytelling for neurodevelopmental disorder users" (Paper ID5)*

5.3 Theme 3: Educational serious games

This theme aggregates ways of using ST by employing educational serious games. The type of platform, application, or technological device is indifferent. Typically, they are used to present museum objects and spaces for learning purposes, even if often the details are lacking, e.g.:

> *"Serious Games have been widely seen in the Cultural Heritage (CH) domain (...) as a novel, unique and useful tool that can shape cultural experiences in an engaging, educative and entertaining way" (Paper ID11)*

It also includes the use of ST in interactive multimedia applications, even if not formally presented as a game, e.g.:

> *"(...) many of (...) [the reviewed studies] encompassed the narrative aspect of creating interactive-multimedia applications (...) [in] informal instructional settings, in museums" (Paper ID9)*

As per the above example, this aggregation does not discriminate per educational approach and includes games and interactive applications even if they consider the museum as an informal or non-formal environment.

5.4 Theme 4: Modify the experience

This theme aggregates ways of using ST to modify the visiting experience specifically by adopting new formats and approaches. Other methods of modifying the experience without innovation in formats/approaches are rather aggregated in other themes, such as "Provide deeper knowledge about content" or "informal exposure". This theme focuses specifically on ST use to provide a differentiated and innovative experience, such as escape rooms or virtual tours:

> *"(...) cultural institution (...) website to (...) give virtual tours" (Paper ID3)*

In this theme are all approaches where there is sharing of stories or appear as protagonists of the experience, such as:

> *"(...) that share stories and experiences with their audience" (Paper ID11)*
>
> *"(...) storytelling is at the core of the experience in the new museological theory" (Paper ID7)*

5.5 Theme 5: Engagement

This theme concentrates ways of using ST in virtual museums to provide the engagement of the external public, promoting future visits, including young people, through tourism promotion and media communication. Example:

> *"The usage of gamification and storytelling fosters the motivation of youngsters to visit places such as museums (...)" (Paper ID4)*

These are actions that aim not only to attract the external public but also to engage it, associating communication and digital marketing actions to promote cultural tourism to different audiences depending on specific subjects or themes. Example:

> *"(...), support cultural heritage promotion, such as (...) museums tourism" (Paper ID1)*

5.6 Theme 6: Reinterpret

This theme represents ways of using ST in museums to provide a new interpretation of objects or spaces, arising from the use of new technological forms of interaction and analysis, or by comparing their current state with the use/period of origin, for example:

> *"The effectiveness of new forms of interpretation such as: "electronic field trips" that reach audiences around the world, storytelling, digital storytelling, chatbots, serious games and virtual heritage interpretation centres" (Paper ID6)*

5.7 Theme 7: Generic virtual museums

This theme aggregates forms of ST use in museums encompassing presentation of museum content as a digital medium, whether focused on recreating the physical museum or in the form of a catalogue with interactive elements, for example:

> *"Content must also be adapted to different, more interactive and more communicative formats. For example, (...) virtual museums" (Paper ID8)*
>
> *"[In a 3D virtual museum framework] The enjoyment feature can be implemented with personalized context-aware (...)" (Paper ID10).*

5.8 Theme 8: Generic digital storytelling

This theme aggregates references to the use of ST, which are lacking any details, and thus are not eligible for inclusion in other themes, whether interactive or not:

> *"(...) techniques such as (...) digital storytelling" (Paper ID3)*
>
> *"Interactive digital storytelling" [in one or more of 65 non-specified papers] (Paper ID5)*

5.9. Results and Discussion

In this section, we reflect on the results of the searches and discuss the themes generated.

Considering the number of codes in each theme, the following distribution of prevalence was obtained, i.e., common or uncommon uses of ST in virtual museums. Figure 5 shows the distribution of the number of codes and Figure 6 the percentage of prevalence:

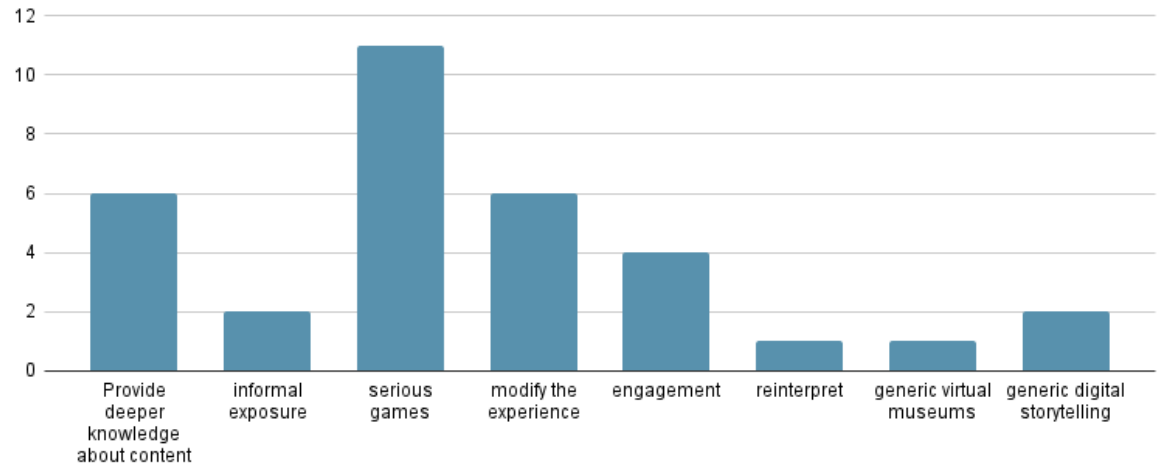

Figure 5. Distribution of the number of codes associated with the themes.

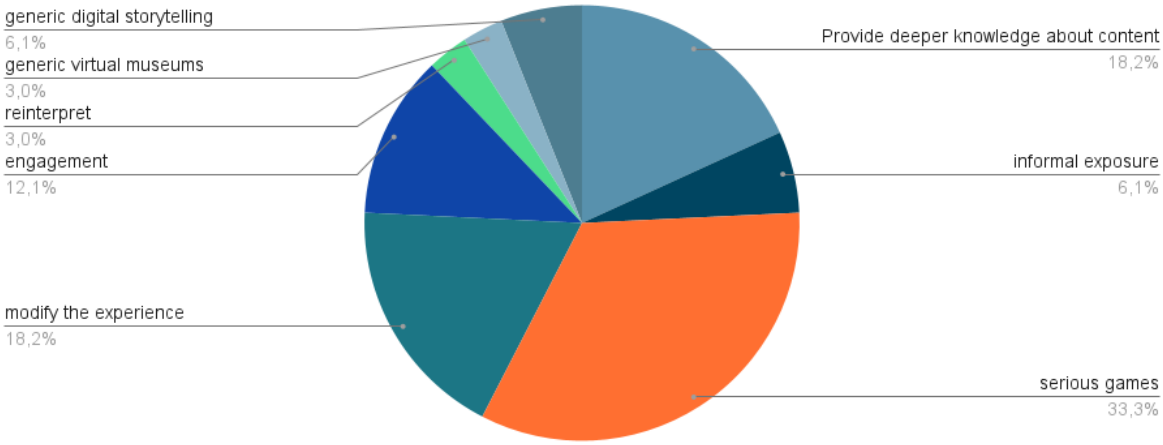

Figure 6. Prevalence of themes according to codes of extracted excerpts.

The theme “Serious Games” has the highest prevalence, about a third of all codes, followed by “Provide deeper Knowledge about content” and “Modify the experience”, with identical prevalence. Other approaches had less prevalence.

Following the theoretical framework of virtual visits by Resta et al. presented in section 2.3, we associated these themes with the categories "navigate" and "interact" (Table 3), according to their most straightforward interpretations:

Table 3. Distribution of themes by modalities.

	Navigate	Interact
Theme 1: Provide deeper knowledge about content	X	-
Theme 2: Informal exposure	X	X

Theme 3: Serious games	X	X
Theme 4: Modify the experience	-	X
Theme 5: Engagement	X	X
Theme 6: Reinterpret	X	-
Theme 7: Generic virtual museums	-	-
Theme 8: Generic digital storytelling	-	-

This association of themes with the modalities is being presented in a broad sense as a possibility of appropriateness, i.e., a virtual tour, brings with it the potential to present detailed content and provide engagement, in the same way that website navigation also does. Although some themes appear in both categories, some are linked to the Interact modality, and fit more easily into technological approaches by referring to "spatial representation" and /or artefacts. On the other hand, themes like Reinterpret or Engagement, are more linked to Navigate for being conceptual or expectable, as a result of the actions of the visit.

Two themes that do not fit the conception of Resta et al: the generic approaches, Themes 7 & 8, which lack specificity to ascertain purpose.

For example, when it is only mentioned in the paper that there is a storytelling or interactive digital storytelling approach without presenting concrete details about how or for what purpose, in addition to being interactive or based on storytelling.

The forms of ST identified in this review were: In theme 1, regarding the physical visit with the aid of technological devices, the use of touch screens, motion capture and augmented reality applications to present descriptions of objects and spaces. When pointing to the navigation on the museum's website, theme 1 appears in the descriptions of images, whether of collections or spaces, as also occurs with the virtual tour modality. In theme 2, ST appears as signage to support and guide the visitor through the spaces, or as specific information without the intention of serving as didactic material. Both the navigation through the physical spaces and the website and virtual tour are conducive to this scenario. In theme 3, considering the aspect of the physical visit with the aid of technological devices, we identify the use of augmented reality applications or multimedia or gamification approaches. In themes 4, 5, and 6, ST emerges as a direct consequence of the approaches and use of technologies. The virtual tour appears as the most propitious to provide the modification of the experience due to its naturally interactive approach.

In this path of analysis of interaction in virtual museums, specifically in the virtual tour modality, some gaps were identified from the literature review (Perry et al., 2017; Lopez Rodriguez, 2020; Rahim et al., 2017) and systematic analysis of the websites of the main museums in the world, described in section 2.2, which are:

- Low level of freedom in navigation;
- Lonely experience;

- Lack of a script to be followed;
- Lack of interaction with the exposed objects.

The evidence found of the use of ST for this type of approach is concentrated on themes 1 and 2, with descriptions or information about the works. However, not all virtual tours present these descriptions, or when they do, they are in insufficient quantity for the number of works exhibited.

Comparing website navigation and virtual tour, both have a low level of freedom and feeling of a solitary experience. Only in website navigation or physical visit aided by technological devices, it is possible to notice cases of use of scripts to follow or objects to manipulate.

6. Conclusions

This literature review was carried out with papers between 2013-2021, and 14 articles were selected to address the identified issue. The museum is currently perceived as a space capable of encompassing several types of experiences, whether through digital and interactive elements or through new approaches that are independent of technology, such as storytelling. However, the museum as a digital space, known as virtual museum, also plays an important role in sharing information and experiences. Contrary to its conception, it has become a very versatile tool, being a complementary space to physical museums with the ability to provide differentiated experiences through modalities such as the virtual tour. As a theoretical reference, a model of navigation flow of visitors in virtual museums was used, which presents two categories: Navigate, for access to collections and other information, and interact, for interactive virtual tour that simulates the physical space. In this context, storytelling approaches emerged as significant in several aspects, which were described and analysed throughout the manuscript.

In this paper, we focused on understanding the role of storytelling and how museums use it. Results suggest there is more diversity in the use of navigation than in interaction, which leads to the conclusion that interactivity has not been explored with the diversity one would expect for its effectiveness in the consequences of public reaction. This points to the need for further work to be done on this aspect.

It was found that the storytelling approach in physical visits is a consolidated practice, even when visitors use their own equipment, such as smartphones or other devices. However, in the virtual approach, its use is still punctual, being up to the user himself, most of the time, to formulate the narrative from the connection of the objects with their descriptions. Therefore, as a field of study there are many publications describing and analysing interactive technologies used in physical museums, but in the virtual tour modality, since no cases of narrative use were found, the potential of this approach to support the resolution of current problems is unknown.

Regarding next steps, we intend to develop a storytelling workshop with stakeholders that will serve as a basis for us to understand the necessary requirements for the creation of a digital storytelling application to be used in the context of virtual museums that meets the problems raised.

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