Innovation, Technology and User Experience in Museums: Insights from Scientific Literature

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Abstract. Museums play an important role in preserving the heritage and cultural legacy of humanity, however, one of their main weaknesses in regards the user is their static nature. At present, and in the face of the development of diverse technologies and the ease of access to information, museums have upgraded their implementation of technologies aimed at improving the user experience, trying more and more to access younger audiences with a sensitivity and natural capacity for the management of new technologies. This work identifies trends in the use of technological tools by museums worldwide and the effect of these on the user or visitor experience through a review of scientific literature. To complete the work, we performed a search of the publications in the Scopus® referencing database, and downloaded, processed, and visualized the data using the VOSviewer® tool. The main trends identified in this context of analysis are related to the role of museums with the development and improvement of the user experience; orientation to young audiences and innovation driven by the user through Interactive Systems, digital games, QR Codes, apps, augmented reality, virtual reality and gamification, among others. The objective of the implementation of new technologies in the context of museums is to satisfy the needs of contemporary communication, for all types of content and aimed at an increasingly digital audience, in order to ensure positive interaction and feedback from ideas with social and cultural changes.

Keywords: User experience · Museum · Literature review · Innovation · VOSviewer

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1 Introduction

Literature points out that innovation as an object of scientific interest is not a new phenomenon and that it had its beginnings since the emergence of humanity itself and has generated great changes in the world order [1]. Similarly, it is considered that organizations that are not able to face technological change and the rapid accumulation of new knowledge will have a lag, mainly in terms of productivity and competitiveness [2].

The implementation of technology in the field of museums became a challenge that has been tilting after a period of transition towards its correct employment, generating new, fascinating and innovative experiences that have managed to increase the interest of people to visit Museums [3–9], to achieve this, tools such as ICT (Information and Communication Technologies) have been used, through which techniques such as interactive or 3D systems were implemented [10–12], generating as a result that children and young people are attracted by this type of mediation.

With the advent of the digital age, these new technologies have been applied in museums to provide more pleasant and educational experiences, implementing interactive screens and digital games, this combination of artifacts allows a positive interaction of feedback of ideas with social and cultural changes [13–16].

Considering the above, it is possible to point out that the use of technology has been a fundamental element in the improvement of the museum experience by visitors [7, 8, 17, 18]. This paper presents a review of success stories in the international context and also a search for information in scientific publications to identify trends through tool VosViewer®.

Technology in Museums

New visitors to museums bring other types of challenges and demands and hope that these spaces will be increasingly creative and innovative in the creation and presentation of content that can encourage society to visit them [11]. However, although the evidence in the literature indicates that the use of new technologies increases the interest of people who visit museums through interactive systems, 3D systems, digital games and other technological means; It is pointed out that there must be a balance when using technologies of static and interactive approach to information as well as entertainment in learning in the museum. Table 1 presents a summary of different types of technological tools or instruments used in some museums of world relevance.

Table 1 shows that currently the way in which museum visits are developed has been expanded, becoming increasingly a cultural and didactic experience through non-contact visits, using technologies that revolutionize teaching/learning activities within museums, showing collections and materials in a creative way.

The objective of the implementation of new technologies in the context of museums is to meet the needs of contemporary communication, for a contemporary art produced by artists framed in these technologies and aimed at an increasingly digital audience. Ensuring a positive interaction of feedback of ideas with social and cultural changes. An important aspect in this context of analysis is that interaction between different aspects of culture is favored, for instance the possibility of real-time interaction between scientists, artists, designers and intellectuals with a wider population.

Table 1. Tools or technology in museums.

Type of tool	Museum	References
Interactive systems, 3D Systems, Digitals games, Dynamus	Sydney Museum Centro de Arte Contemporáneo de Málaga Museo de Artes de Berlín Museo Arqueológico Nacional de Madrid London Brithish Museum Museo de Bellas Artes Bilbao Petrie Museum Museo de Lisboa Penang State Museum Negara Museum	[19–26]
Codes QR, Applications for mobile devices	Museo de Muesca de España Bernasconi de Argentina Museo Art Nouveau y Art Deco Casa Lis de España Museo de Arte Moderno de Santander España Museo Irlandes de Arte Moderno (IMMA)	[3–28]
Touch experience and augmented reality	UNESCO Underground gallery of Yunnan anti-Japanese victory memorial hall Tate Britain Art Gallery	[29–34]
Artistic healing tools WeCurate	London Museum	[12, 35–38]
Augmented micro reality	Grant Museum of Zoology	[39]
Smart Glasses	Robotics Gallery at the MIT Museum	[16]
Augmented reality, holographic computing	The Royal Ontario Museum Kangmeiyuanchao Zhanzheng in Chinese (KMYC) memorial hall Changsha Museum	[24, 40–45]
Olfactory Experience	Macao Museum of Art Tate Britain Art Gallery Jason Bruges Studio United Visual Artists	[31, 46, 47]
Gamification, Virtual Museum, Twitter, Serious Games	Sagamihara City Museum The 30th anniversary of a famous half-marathon held annually in the United Kingdom called The Run	[4, 43, 48]

Bibliometric Mapping with VOSviewer

Two aspects of bibliometric mapping that can be distinguished are the construction of bibliometric maps and the graphical representation of such maps. VOSviewer is a program that we have developed for constructing and viewing bibliometric maps. The program offers a viewer that allows bibliometric maps to be examined in full detail. VOSviewer can display a map in various different ways, each emphasizing a different aspect of the map. It has functionality for zooming, scrolling, and searching, which

facilitates the detailed examination of a map. The viewing capabilities of VOSviewer are especially useful for maps containing at least a moderately large number of items (e.g., at least 100 items). Most computer programs that are used for bibliometric mapping do not display such maps in a satisfactory way. To construct a map, VOSviewer uses the VOS mapping technique [49], where VOS stands for visualization of similarities. VOSviewer can display maps constructed using any suitable mapping technique. Hence, the program can be employed not only for displaying maps constructed using the VOS mapping technique but also for displaying maps constructed using techniques such as multidimensional scaling. VOSviewer runs on a large number of hardware and operating system platforms and can be started directly from the internet.

2 Methodology for the Identification of Trends

The scientific production registered in Scopus® about museums and innovation has been analyzed from 677 publications for the period 1959 to 2018. The methodology aims to identify trends in the global production of the field of analysis. For this, four phases are developed that allow a systematic review of the literature.

- *Phase 1. Definition of guiding questions:* The following were considered: what is the relationship between museums and innovation? Who are the main authors and institutions in this area?
- *Phase 2. Search in specialized database:* The Scopus® database was selected and a total of 677 records were obtained for the period 1959–2018. Scopus® compiles results from other bibliographic databases and independent scientific publications.
- *Phase 3. Download of bibliographic records:* Once the records were identified, they were downloaded using the tools offered by Scopus®. For this stage, the CSV format was used that facilitates its subsequent processing using Excel® 2016.
- *Phase 4. Consolidation and analysis of information:* Tools such as dynamic tables and macros were used in Excel® 2016 to generate the input data for graphing in VOSviewer®.

3 Results

A selection of results obtained in this work is presented. In this sense, the search equation that is used in the selected database is generated from the guiding questions identified, being as follows:

$$TITLE-ABS-KEY\ (innovation\ AND\ museum)$$

The first publications identified in Scopus® that relate the terms innovation and museums date from 1959, but it is from the end of the 90's that there is a significant and sustained growth in the number of publications on this subject. For the study period

there is the contribution of authors with more than 5 publications such as María José Garrido, Carmen Camarero Izquierdo and Derek Walker.

The number of times a scientific article is cited in other studies often represents the key indicator in assessing the impact of authors in the field of science in which they are working [49]. In this regard, it is important to highlight the work of authors such as Wolfram Bürgard of the Department of Computer Science of the University Freiburg im Breisgau, Germany with a total of 442 citations of his 1999 article that describes the software architecture of an autonomous tourist guide robot and interactive for museums [50].

In recent years, technology has evolved on a large scale. Game engines have been developed and web platforms have reached their highest levels. This is why it is decided to use this degree of maturity to contribute significantly to the mix of cultural education and education through play. In this sense, the works with greater relevance are oriented to the use of technologies such as augmented reality, virtual reality, human computer interaction and digital storage [24, 25, 44, 48].

An analysis of the output of the keywords identified in the search allows identifying clusters or groups of terms that give light on the orientation of scientific production in this field. It is possible to identify five clusters highlighted with different colors. See Fig. 1.

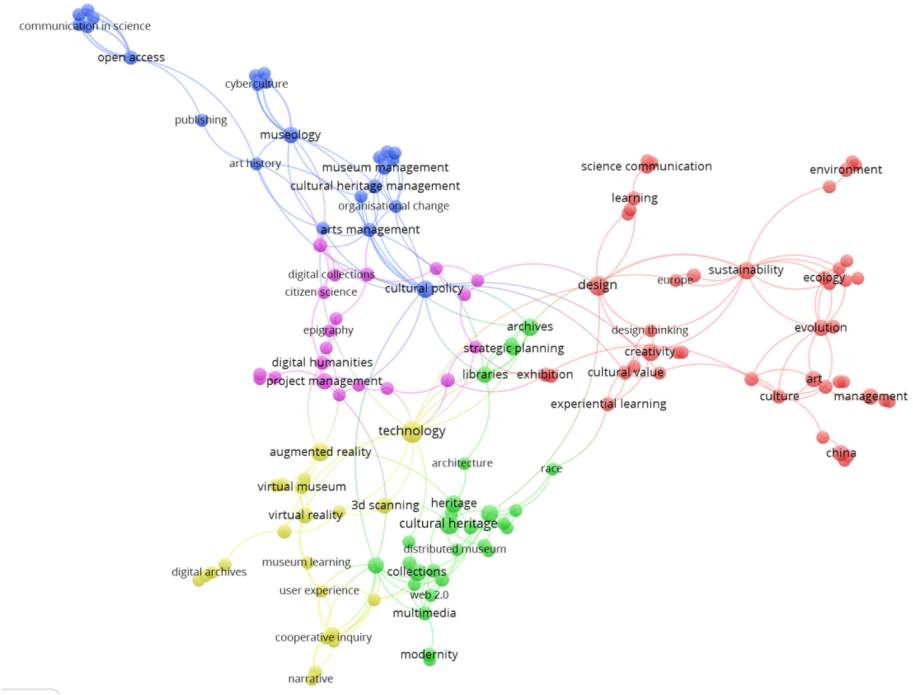

Fig. 1. Display of clusters generated in the text body. (Color figure online)

3.1 Cluster 1

Identified with the color red groups works around the creation of value in the learning process based on experiences through design thinking, encouraging creativity in the visitor [10, 35, 51–53]. Similarly, these works are related to the concept of sustainability through the use of technology in museums [54–56]. See Fig. 2.

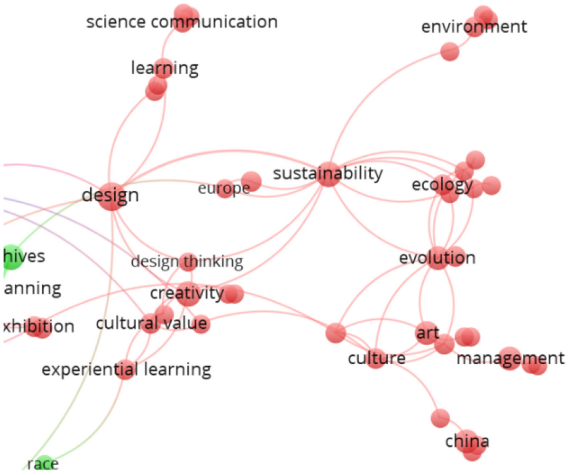

Fig. 2. Cluster 1 display (Color figure online)

3.2 Cluster 2

Cluster 2, identify with blue color, is formed by works on the advantages that technology generates in the area of museum management and cultural heritage [51, 53, 57] and its contribution to the creation of Science Communication, cyber culture and cultural heritage [58–60]. See Fig. 3.

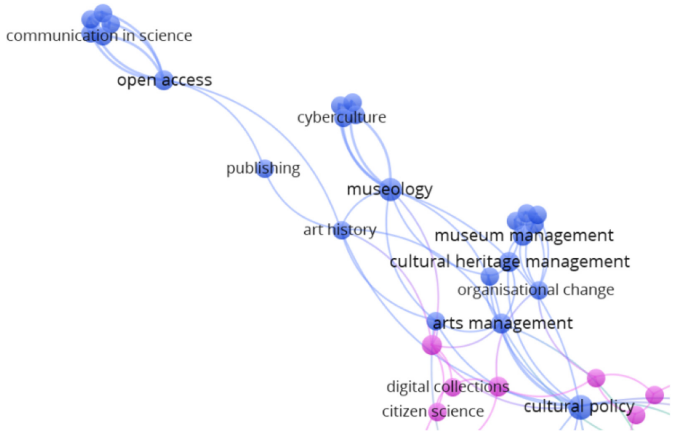

Fig. 3. Cluster 2 display. (Color figure online)

3.3 Clusters 3 and 4

Cluster 3, identified by the color green groups publications related to architecture for the storage and management of cultural heritage in museums [61–65]. For its part, cluster 4, identified with the color yellow, brings together works around the use of technological tools such as virtual reality, augmented reality, 3D scanning, cooperative consultation and digital archives, likewise their effect on narratives and user experience [66–69]. See Fig. 4.

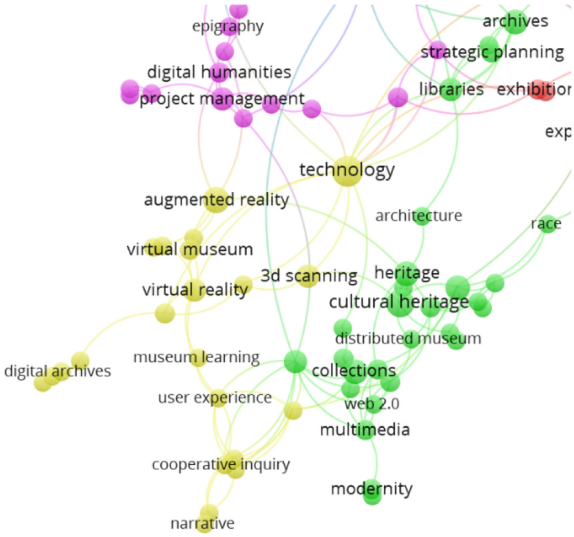

Fig. 4. Clusters 3 and 4 display. (Color figure online)

3.4 Cluster 5

Finally, cluster 5 identified with the magenta color groups works that deal with aspects related to the creation of cultural identity and the role of new technology in museums, facilitating the creation of digital heritage and collaborative learning [24, 25, 30, 45, 67, 70–72]. See Fig. 5.



Fig. 5. Cluster 5 display. (Color figure online)

3.5 Identification of Trends in the Literature

To identify trends in scientific publications for the body of text analyzed, we made use of a functionality of the overlay visualization tool of the VOSviewer®, which allows to identify by color key, the most recent terms that identify themes in scientific production. A description of the elements identified as a trend in the context of museums is presented below.

- *Branding:* Museums can facilitate the construction of a unique narrative using culture, heritage, innovation, creativity, technology, etc., to create symbolic value over a particular place, city, territory or cultural event. Beyond the place, brand channels, such as the media, disseminate images and sounds, creating and publicizing the brand narrative created by culture [73–76].
- *Library Development:* Innovative personnel and financing strategies will be particularly useful for organizations facing monetary and personnel shortages and highlight collaborative management practices [74, 77].
- *Archaeology:* The use of technological resources at the service of didactic interpretation for educational purposes (APPs, QR codes, VR and AR) that allow the development of virtual archeology (virtual reconstructions and recreations, augmented reality, etc.) through mobile devices. For this, different educational innovation and research projects have been taken into account, based on the visualization, manipulation, classification or construction of virtual objects of an archaeological nature, some of them in the environment of collaborative social networks, which allow creating, pointing out, affirm, argue, search, cite and justify archaeological investigations [78–81].
- *Development and improvement of User Experience:* Creating a pleasant experience in the museum, while providing an experience of entertainment and education, is one of the motivations for the use of technological tools in museums. QR codes, VR and AR type technologies, among others, have always had the attention of industry and users. Due to the influence of science and technology, the projects of new museums and remodeling or development projects of the current ones, go through the use of such tools to improve the user experience [64, 78–81].
- *Teenagers:* Digital technologies can make it easier for museums to promote and create immersive experiences for young audiences. Especially through the use of digital narratives, location-based games and game-based learning [79, 81].
- *Cooperative Inquiry:* Cooperative research (IC) offers important opportunities for the academic world to transform the teaching process with collaborative practices at different levels of education in a variety of disciplines. In the context of museums, it is actually used to develop co-design sessions to devise the interactive experience of the museum [79, 81].
- *User Driven Innovation:* User-driven innovation can generate ideas and contribute significantly to the profitability and success of a company. Users serve as extended endogenous innovation personnel, where behavioral documentation and direct feedback allow proactive changes in products, services and processes, impacting in competitiveness [56, 79, 81, 82].

4 Conclusions

Museums, as active actors in strengthening universal culture and facing their institutional responsibility towards society, have taken on the challenges of the digital era by adopting forms of communication based on highly interactive technological mediations and incorporating innovative interfaces that allow them to remain in the imaginary as an attractive option for new generations.

The incorporation of technologies such as 3D Systems, QR Codes, Smart Glasses, Augmented Reality, and Holographic Computing, among others, have become mechanisms to provide new codes, narrative forms and mediations that strengthen the concepts of inclusion, immersion and participation, which transcend the traditional way of visiting the museum.

Without a doubt, the incorporation of new technologies in the work of museums opens up a wide range of areas of intervention that imply changes in the dynamics of interaction, in institutional processes and, above all, in the user experience.

In this order of ideas, one of the most significant aspects is the generation of knowledge, collaborative learning and the strengthening of culture based on experimentation; Other important aspects to consider are the generation of digital and multimedia content that support the conservation of cultural property and the massification of the work of the museum, overcoming geographical and temporal barriers through the use of technological convergence. Finally, the implementation of technological innovations fosters the creation of new business models based on new forms of interaction, the generation of added values and the monetization of emerging alternatives for assets accessibility.

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